

# ASSESSING MARKETING AND AID STRATEGIES TO STIMULATE ECONOMIC GROWTH IN SUB-SAHARAN AFRICA

BY

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DISSERTATION

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## ABSTRACT

Stimulating economic development and growth has been difficult in Sub-Saharan Africa (SSA). In this three-essay dissertation, I examine and assess two strategies—market-based risk management through hedging, and growth through aid—that could potentially facilitate growth in SSA.

Since many SSA countries derive a considerable portion of their total export revenues and foreign exchange from the exports to highly volatile commodity markets, risk management strategies are viewed as viable methods to reduce the negative effects of risk on development and growth (Razzaque, Osafo-Kwaako and Grynberg, 2007). Here I investigate the usefulness of futures markets for hedging price, production and hence, revenue risk in the cocoa market, a commodity particularly important to SSA countries such as Ghana, La Cote d'Ivoire (CIV), Nigeria, Togo, Uganda, and Cameroon. An ability to hedge commodity-market volatility reduces terms-of-trade risk, leading to a more effective allocation of resources (Ramey and Ramey, 1995).

The effectiveness of aid in stimulating growth is controversial (Bruckner, 2011; Naito, 2010; Leeson, 2008; Collier, 2007 and Easterly, 2006). Highly diverse economic situations, economic programs, and political instability make it difficult to identify when aid will have a positive effect on growth. I examine factors that stimulate economic growth in SSA using recent data, while addressing endogeneity problems that typically plague the aid-growth relationship. In particular, I focus on the relationship between political stability, foreign aid and growth because although political stability is a pertinent factor affecting growth in SSA, the empirical literature has largely ignored its influence until very recently. The existing literature concludes that good macroeconomic policy is the crucial factor in determining efficacy of aid in stimulating growth,

basing this conclusion on Burnside and Dollar's (2000) finding of a significant aid-policy effect.

Similar to Islam (2005), I challenge the existing view that good policy is sufficient to make aid work. Specifically, I investigate whether political stability is a more pertinent determinant of the aid-growth relationship in SSA. The aid literature has also not critically evaluated the validity (exogeneity and strength) of the instruments used to correct endogeneity bias in aid-growth regressions. Following Deaton (2008), I evaluate the applicability of instrumental variable techniques to the estimation of the aid-growth regressions for SSA.

The dissertation consists of three essays. Essay 1 is concerned with the role of political stability in the use of aid as a growth strategy. It characterizes the economic relationship between aid and growth and determines how political stability affects the aid-growth relation in SSA. Appropriate econometric procedures are used to mitigate endogeneity bias due to unobserved, time-invariant country-specific effects and to simultaneity in the aid-growth regression.

Essays 2 and 3 focus on the use of market based-strategies to minimize market risk in order to enhance growth. Essay 2 determines whether cocoa futures markets are biased and inefficient either in the long or short run using five and two-month cocoa maturities. The paper also establishes if any short-run bias in the futures forecast of cash prices is due to a risk premium or to informational inefficiency. The presence of a risk premium will result in biased futures forecasts of subsequent periods' spot prices. The absence of a risk premium in a futures market is thus a favorable condition for using the futures market to manage commodity market risk. Hedging is feasible if a risk premium exists but it may not be practical if returns are low.

Finally Essay 3 investigates if hedging revenue risk is utility improving for a sovereign cocoa exporter like Ghana using a five month pre-harvest to harvest hedge. This is done by determining if optimal hedge ratios for cocoa exporter remain positive for a range of relevant

risk parameters after transactions costs are incorporated into the cocoa exporter's utility maximization problem. The presence of utility-enhancing hedging may stimulate market returns and create an environment conducive to growth and development.

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# ESSAY 1: DOES POLITICAL STABILITY IMPROVE THE AID-GROWTH RELATIONSHIP? PANEL EVIDENCE FOR SELECTED SUB-SAHARAN AFRICAN COUNTRIES

## 1.0 SUMMARY

Significant ambiguity still surrounds the aid-growth relationship despite fifty years of research on the subject. For the case of Sub-Saharan Africa (SSA), a possible reason for the lack of consensus is that until recently the influence of political stability on the aid-growth relationship had been largely ignored despite its relevance for the region. Further, although overlooked by the literature, the Instrumental Variable (IV) technique, the preferred treatment method of endogeneity in aid-growth relationships, may be ineffective in eliminating endogeneity bias because typical instruments for aid are neither sufficiently exogenous nor strong. Using a dataset of 31 SSA countries from 1984-2007, we re-visit the question of whether aid can spur growth in SSA using first-differencing (FD) to eliminate unobserved-effects endogeneity while focusing on the role of political stability on the aid-growth relationship in SSA. Results suggest aid promotes growth conditional on political stability in SSA and that First Differencing (FD) eliminates a substantial amount of the endogeneity bias. Our results demonstrate the pertinence of a stable political environment for attaining the UN's Millennium Development Goals (MDGs) for SSA countries since these goals inherently assume that aid can promote growth.

## 1.1 INTRODUCTION

Despite repeated warnings by economists of its futility, the developed world still provides substantial aid to Sub-Saharan Africa (SSA) to spur economic growth (Leeson, 2008 and Arndt, Jones and Tarp, 2010). SSA has absorbed almost one trillion nominal aid dollars over the last fifty years but the growth record has been unimpressive (Mayo, 2009 and Easterly, 2006). The insistence of developed countries to bestow aid on SSA is not so confounding if one considers



that ambiguity still surrounds the effect of foreign aid on growth (Naito, 2010 and Bruckner, 2011). In particular, estimation of the aid-growth relationship is fraught with different kinds of endogeneity problems (Rajan and Subramanian, 2008 and Deaton, 2008). Further, since SSA has been racked by political instability, a question emerges about the effect of political stability on the aid-growth relationship in the region.

Given the uncertainty about the effect of aid on growth, and the possible consequences of political stability on the aid-growth relationship, this paper seeks to: (1) empirically determine if aid and growth are related using recent SSA data, and (2) identify the effects of political stability on the aid-growth relationship in SSA after accounting for possible endogeneity bias.

The article contributes to the literature in three main ways. First, it focuses on the SSA region and employs recent data in estimating the effect of political stability on the aid-growth relationship. Second, it uses a dependable measure of political stability constructed with the Political Risk Service (PRS)'s International Country Risk Guide (ICRG) dataset to identify the effect of political stability on the aid-growth relationship in SSA. Finally the possibility of endogeneity bias is addressed; the current literature treatment of endogeneity with IV is criticized while FD is justified and employed in estimating the aid-growth regression. Aid is found to be positively and significantly related to growth in SSA conditional on political stability after minimizing endogeneity bias. This result confirms Islam's (2005) finding that aid promotes growth in stable but not in unstable LDCs.

## 1.2 LITERATURE REVIEW

There are valid theoretical arguments as to why the effect of aid on growth might be positive, negative, linear, nonlinear or even ambiguous (Minoiua, and Reddyb, 2010; Easterly, 2006 and Hansen and Tarp, 2001). On one hand, "Gap theory" contends that aid promotes growth by augmenting the investment and foreign exchange needed for production and growth (Chenery and Strout, 1966). On the other hand, countries that receive aid might consume it, leading to aid-dependence (Bauer, 1984, 1991 and 2000; Mayo, 2009; Rajan, and Subramanian, 2011 and Arndt, Jones and Tarp, 2010). Clearly, aid might hurt or promote growth, so the effect of aid on growth remains an empirical question (Rajan and Subramanian, 2008 and Bruckner, 2011). Comprehending the exact relationship between aid and growth is, however, crucial to SSA countries and donors as they seek to realize the UN's Millennium Development Goals

(MDGs) which inherently posit that aid is growth-promoting (see the Appendix A at the end of the dissertation for details of the eight MDGs). The stated aim of the MDGs is to halve severe \$1/day poverty between 1990 and 2015 using aid as one strategy (Sachs, 2005 and Collier, 2007) so it's vital to ascertain with a reasonable degree of confidence how aid affects growth in SSA.

Entangled in the debate on how aid affects growth are differences in the structure of the economic model, the context under which aid is effective, the econometric procedures employed and the data used. In particular, the effect of aid on growth is likely to be context-specific therefore identifying the salient features of the context has received a lot of attention in the literature. Burnside and Dollar (2000) (henceforth BD (2000)) identified good macroeconomic policy as the salient contextual condition for aid to promote growth. They found that the aid-growth relation is positive for countries that maintain sound economic policies but negative for countries with inappropriate policies, basing their result on a positive and significant interaction term involving aid and policy. BD (2000) included a dummy for SSA which proved to be negative and significant in aid-growth regressions, indicating that the aid-growth effect may be different for SSA. This point is noteworthy as effective policy might be insufficient to guarantee the efficacy of aid in promoting growth in SSA. Not surprisingly, the contention that aid promotes growth given good policy has been successfully challenged in the literature. For example, Easterly, Levine and Roodman (2004) showed that the positive aid effect given good policy disappears when either more time series data or different countries are used in the data set. In contrast, Islam (2005) finds that the aid-growth relationship must be conditioned on political stability, not macroeconomic policy as political stability is the more pertinent determinant of the efficacy of aid in stimulating growth.

Like Islam (2005), our objective is to investigate whether political stability influences the aid-growth relationship. However, we limit our dataset to SSA because this is our region of interest and because SSA appears to experience relatively high levels of instability. We investigate the effect of political stability on the aid-growth relationship and address two types of endogeneity also identified by Hansen and Tarp (2001): (i) simultaneity (caused by feedback from growth to aid) and (ii) unobserved-effects endogeneity caused by correlation between latent, time-invariant (and or time-varying) country-specific effects in the error matrix and the matrix of right hand side variables. Both types of endogeneity can cause bias in OLS estimation of aid-growth relationships so their deleterious effects need to be properly mitigated.

While the aid-growth literature is only now focusing on reducing bias due to unobserved effect endogeneity, it abounds with attempts to control simultaneity bias using IV. There is however limited literature that focuses on evaluating whether the typical instruments for aid used in IV estimation of aid-growth regressions such as population satisfy the exogeneity and strength criteria defined for valid instrumental variables analysis (Deaton, 2008). This research will help close that literature gap. For example, population may be endogenous in the growth equation for SSA countries; this implies that in contrast to the IV treatment of the endogeneity of aid by Islam (2005), Burnside and Dollar (2000), and majority of the aid literature, typical instruments for aid may actually be invalid instruments for aid. Colonial legacy (Islam 2005) and rainfall (Bruckner, 2001), however, may be argued to be exogenous instruments for aid since they are not determined by contemporaneous economic performance. However, they are not excludable; that is, they belong to the true model and should enter the growth equation as explanatory variables and should not be used as instruments. Finally, except for Deaton (2008) the literature has not focused on evaluating the “strength” of instrument for aid in aid-growth regressions.

### 1.3 EMPIRICAL MODEL

The model used in this paper is a modified version of Islam’s (2005) empirical aid-growth model which was derived from Solow’s (1956) theoretical growth model and is standard in the aid-growth literature. Following Islam (2005), aid is hypothesized to affect growth through its effect on savings and investment. Political stability affects the aid-growth link through its effect on the ability of a nation’s citizens to accumulate capital, save, invest and innovate (Hansen and Tarp, 2011). In particular a stable political environment can lead to effective economic policies and correct investment decisions both of which can spur growth. In a stable political environment, aid is then just new capital and should logically contribute to growth (Hansen and Tarp, 2001). The effects of political stability on the aid-growth relationship can thus be captured in the empirical model by the interaction between political stability and aid. The empirical growth model employed is presented in (1)-(3) and used to investigate the relationship between economic growth and foreign aid, as well as the effects of political stability on the aid-growth relationship in SSA.

$$(1) \quad GROWTH_{it} = \gamma_0 + \gamma_{AID} AID_{t-1} + \gamma_{AIDSQ} AID^2_{t-1} + \gamma_{AIDPS} AIDPS_{t-1} \\ + \gamma_{PS} PS_{t-1} + \gamma_{SQPS} PS^2_{t-1} + Z_{it} \gamma_Z + \varepsilon_{it}$$

$$(2) \quad \varepsilon_{it} = \varepsilon_i + v_{it}$$

$$(3) \quad v_{it} \sim N(0, \sigma^2)$$

*GROWTH* is GDP per capita growth, *AID*, is foreign aid or Official Development Assistance (ODA),  $AID^2$  is the square of *AID*, *PS* is political stability,  $PS^2$  is the square of political stability, *AIDPS* is the interactions of *PS* with *AID*, and  $\gamma_0$  is the overall constant. The vector *Z* includes variables that control for initial conditions affecting growth, and recent literature provides guidance for their selection (Islam, 2005). *Z* contains variables such as initial level of income (represented by initial GDP or *IGDP*), standard deviation of aid (*STAID*), level of education (*PRIM*), quality of institutions (represented by international country risk guide (ICRG)'s quality of bureaucracy and democratic accountability variables, *BQUAL* and *DACC*), government consumption as a portion of GDP (*GCONS*), and the money supply as proportion of GDP or ( $M_2$ ). Different from Islam (2005) but consistent with Rajan, and Subramanian (2011), Arndt, Jones and Tarp (2010) and Minoiua and Reddyb (2010), we explicitly specify the unobserved effects which are likely correlated with the explanatory variables in the error term. Thus,  $\varepsilon_{it}$  is a composite error consisting of a country-specific component,  $\varepsilon_i$  and an *iid* error term,  $v_{it}$  which has variance  $\sigma^2$ . We include a set of time dummies, one for each four-year period, to account for potential cyclical effects such as downturns in the world economy that may affect the aid-growth relationship.

The sign of the relationship between aid and growth remains an empirical question and may depend on the countries examined (Easterly, 2003). Political stability is expected to positively promote growth. While quality of institutions, level of education and the money supply variables are expected to be positively related to growth, government consumption and the standard deviation of aid are expected to be negatively correlated with growth. Initial GDP will also likely reduce growth as dictated by conditional convergence (Barro, 1996). Following Easterly, Levine, and Dollar (2004) the square of aid is also included as a regressor in the growth equation to account for other possible types of non-linearity.

#### 1.4 DATA DESCRIPTION AND SUMMARY STATISTICS

The aid data are from *SourceOECD* while the political stability data are from the Political Risk Service (PRS) and are described in detail later in the paper. Aid as used here refers to Oversees Development Assistance (ODA) typically given to poorer countries by richer donors

and is exclusive of non-ODA aid. According to the development Assistance Committee (DAC) of the Organization for Economic Cooperation and Development (OECD), there are two main types of ODA aid; multilateral and bilateral aid. About 30% of ODA aid is multi-lateral aid and the remaining 70% is bilateral aid. Total ODA is used in this research. ODA donor countries all belong to the OECD and together donate about 80% of total worldwide aid. China and India have recently become significant donors together accounting for more than 10% of total current aid but such aid is not ODA aid and is not considered in this research. Private organizations provide 10% of worldwide aid (OECD).

The growth data and the remainder of the data are from the World Development Indicators (WDI) of the World Bank, the Penn World Tables, and the World Banks' Africa Database CD. The data come from 31 SSA countries for which data were available (see Table 1.1 for a list), range from 1984 to 2007 and cover six four-year periods (i.e. 1984-1987 to 2004-2007). Apart from possible sample selection bias that may emerge since not all SSA countries are included in the dataset, there are also missing observations leading to an unbalanced panel.

It is also plausible that countries with worse institutions (or more likely to be afflicted by war) are less likely to have good quality data so they are not part of the sample. Such countries are perhaps also more likely to have a zero aid-growth relationship; so their absence would bias OLS results upward. Note, however, that the included SSA countries are spread within the SSA region and there is no evidence of a well-defined data generating process by which the SSA countries were picked therefore sample selection bias is unlikely to be too severe. With regards to missing data, of the 186 observations, 90 % of the data have complete sets of observations so the missing data problem will have limited consequence in OLS estimation even if more data are lost through lagging or first differencing.

Table 1.1 Descriptive Statistics of Key Variables

Variable	Description	Mean (SD)	Min / Max
Growth in per cap GDP (GROWTH)	Based on real GDP per capita in constant US dollars. <sup>a</sup>	0.400 (4.76)	-14.08 (32.13)
Initial GDP (IGDP) * \$ 100 000 000	Real GDP per capita in the last year preceding the period for which the growth rate is calculated. <sup>a</sup>	688.93 (937.94)	56.52 (4599.0)
Aid (AID)	Net Oversees Development Assistance (ODA) disbursements as a percentage of GDP. <sup>b&amp;c</sup>	0.19 (0.25)	0.001 (1.70)
Primary Schooling (PRIM)	Years of primary education. <sup>a</sup>	6.16 (0.71)	4.00 (8.00)
Financial Depth (M <sub>2</sub> )	Money and quasi-money (M <sub>2</sub> ) as a percentage of GDP. <sup>a</sup>	25.03 (35.04)	-8.10 (368.4)
Life Expectancy (LE)	Life expectancy at birth, total (years). <sup>a</sup>	46.24 (12.49)	10.00 (63. 06)

Table 1.1 Continued

Political Stability (PS)	This is an assessment both of the government's ability to carry out its declared program(s), and its ability to stay in office. <sup>f</sup>	6.8130 (2.4091)	1.70 (10.700)
Government Consumption (GCONS)	Gov consumption expenditure as a percentage of GDP. <sup>a</sup>	15.3340 (6.454)	5.9 (50.1)
Time Dummies	Each Dummy takes a value of 1 for particular period and 0 otherwise. The six 4-year time periods start from 1984-1987 and end with 2004-2007. <sup>e</sup>		0.000 (1.000)
Standard Deviation of AID	Square root of the variance of AID	1.52 (0.0002)	0.17 (0.200)

Variable	Description	Mean (SD)	Min (Max)
Investment profile (INVPROF)	Assessment of factors affecting risk to investment not covered by other political risk components. Ranges from 0-12. 12 is very low risk and 0 is high risk. <sup>f</sup>	5.779 (2.074)	0.500 (10.80)
Democratic Accountability (DACC)	This is a measure of how responsive government is to its people. The minimum is 0 and represents the highest risk. The maximum is 6 and represents lowest risk. <sup>f</sup>	2.605 (1.124)	0.200 (5.60)
Bureaucratic Quality (BQUAL)	This is a measure of the quality of the bureaucracy. Ranges from 0-4 with 4 being the lowest risk. <sup>f</sup>	1.4130 (1.025)	0.000 (4.00)

Sources. <sup>a</sup> World Development Indicators; <sup>b</sup> OECD-DAC's online SourceOECD database; <sup>c</sup> World Bank's Africa Database; <sup>e</sup> Constructed variable; <sup>f</sup> International Country Risk Guide (ICRG) of Political Risk Services (PRS).

Note: The SAA countries in the analysis include: Angola, Burkina Faso, Cameroon, Congo, Congo DR, Cote d'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Namibia, Niger, Nigeria, Senegal, Sierra Leone, Somalia, South Africa, Sudan, Tanzania, Togo, Uganda, Zambia and Zimbabwe.

Table 1.1 on the previous page contains definitions and descriptive statistics of variables based on six four-year observations and provides detailed information about data sources and transformations of key variables used in the growth regressions in (1-3). The conversion of the annual data into four year periods is consistent with the time it takes for aid to manifest into growth (Moreira, 2005 and Clemens, Radelet and Bhavnani, 2004). Correlations between the main explanatory variables used in the analysis are presented in Table 1.2 on the next page. The correlations between the variables are low, typically less than 0.4, indicating that multicollinearity is not severe and should not distort statistical inference. Aid is negatively correlated to political stability and initial GDP, respectively (-0.19) and (-0.24), implying aid is not systematically allocated to politically stable countries.



Table 1.2 Correlation Matrix of Selected Explanatory Variables

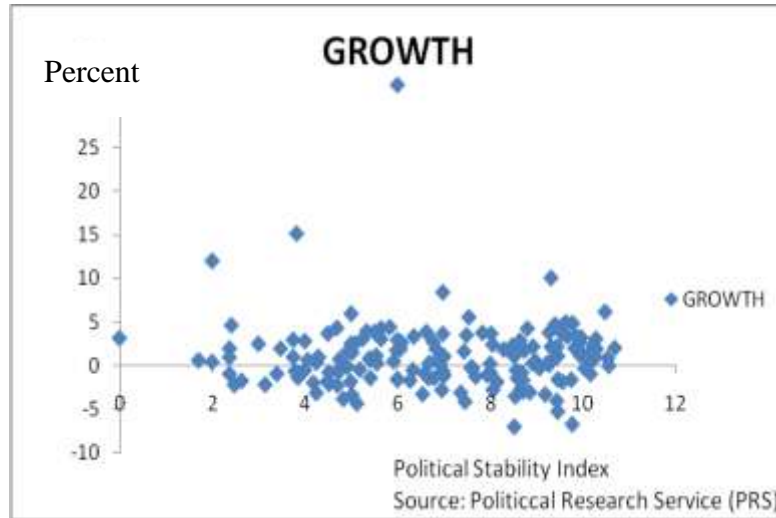
	IGDP	Aid	POL	PS	PRIM	M <sub>2</sub>	BQUAL	DACC	LE	GCONS	NVPROF
IGDP	1										
AID	-0.197	1									
POL	-0.064	0.364	1								
PS	-0.01	-0.249	0.083	1							
PRIM	0.032	0.207	-0.03	0.091	1						
M <sub>2</sub>	0.304	0.13	0.199	-0.108	0.422	1					
BQUAL	0.369	-0.24	0.003	0.004	-0.098	0.142	1				
DACC	0.116	-0.173	-0.02	0.308	-0.026	-0.191	0.205	1			
LE	-0.055	0.132	-0.09	-0.237	0.2141	0.105	0.328	-0.0638	1		
GCONS	0.061	0.111	0.229	-0.319	-0.305	0.168	-0.0262	-0.0868	-0.14	1	
INVPROF	0.053	-0.164	0.179	0.7	0.0915	-0.056	0.1042	0.482	-0.29	-0.208	1
LANDL	0.356	-0.326	-0.07	0.05	-0.292	0.075	0.444	-0.0056	0.243	-0.225	0.034

Figure 1.1 provides a plot of the measure of political stability (PS) against growth rates. The PS measure is an assessment of the quality of governance, the government's ability to carry out its declared program (s) and its ability to stay in office. The rating is the sum of three subcomponents, each with a maximum score of four points and a minimum score of zero points. The subcomponents of the PS measure are government unity, legislative strength and popular support. For each subcomponent, a score of four points equates to very low risk and a score of zero points to very high risk. As a consequence of how its subcomponents are defined, a PS score of twelve points equates to very low risk (stable) and zero points to very high risk (unstable).

The PS measure was constructed using data from PRS's International Country Risk Guide (ICRG) dataset which covers 182 countries from 1980-2008 and is widely considered by political science researchers as the most reliable and comprehensive data on political stability available. The PS measure makes sense for the principal argument of this paper since good governance, and a lack of conflict reflected in government unity, legislative strength and popular support contributes to growth by making aid more effective. The sub-components of the PS capture the milder forms of political stability which likely affect the aid-growth relationship even in the absence of catastrophic events such as wars making the PS measure the best one for our purposes. Further, note that although the ICRG data have been widely used in the literature on corruption and governance, (see La Porta, Lopez-de-Silanes and Shleifer, (1997)) its use is not as widespread in the aid and growth literature. The popularity of the ICRG data have however, increased recently as Knack and Keefer (2001) and Brautigam and Knack (2004) both employed PRS's ICRG data to study the impacts of aid on institutions and governance in SSA while Rajan and Subramanian (2008), Arnd et al (2010), and Minoiu and Reddy (2010) employ the measure in aid-growth regressions. These authors reported that the political stability measures provided meaningful and intuitive findings. It is also noteworthy that the PRS data accurately capture changes in historical political stability among countries and over time as will be explained. Further, other more "recent" governance indicators e.g. Mo Ibrahim's index of governance provide rankings of countries which are consistent with the political stability measure used in this study providing some comfort that our measure is accurate. A final attribute of the PRS's ICRG

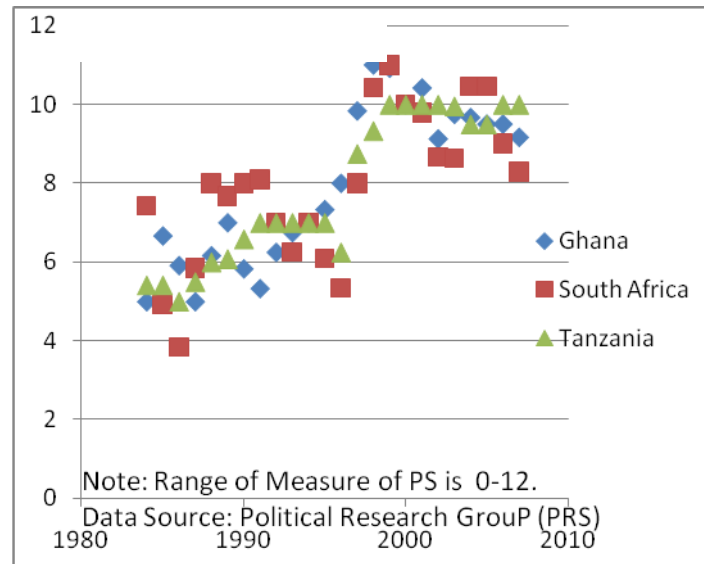
dataset is that it provides the widest range of stability data both in terms of the number of SSA countries available and years covered and uses a well-documented and reliable method where country experts rate countries over time and is thus a perfect fit for our purposes. It is possible to have slight differences in PS scores for particular countries say for Liberia relative to Ghana and South Africa in terms of ex post accuracy of forecast which may reflect the bias of the experts measuring the stability conditions. However such biases are likely to be time-invariant and will disappear when FD estimation is employed as was done in this paper.

Figure 1.1 Growth versus Political Stability, all SSA Countries, 1984-2007



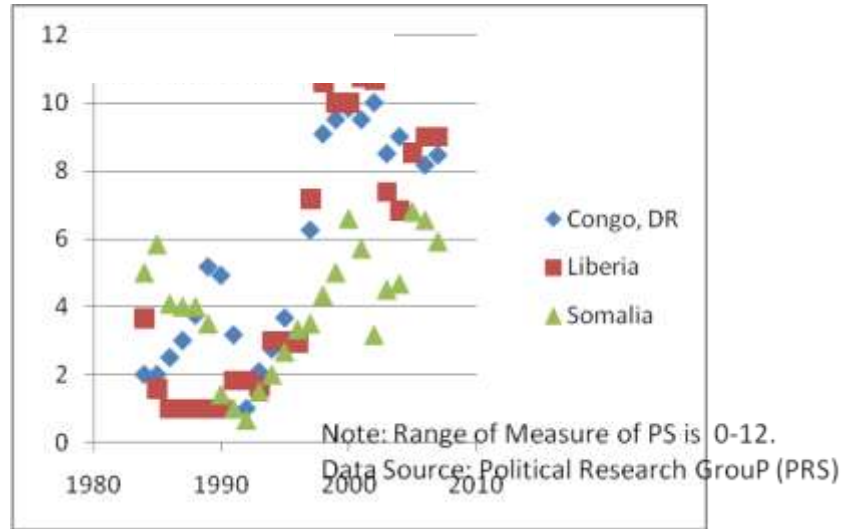
Data Source: Political Risk Service (PRS)

Figure 1.2 Political Stability for the Most Stable SSA Countries, 1984-2007



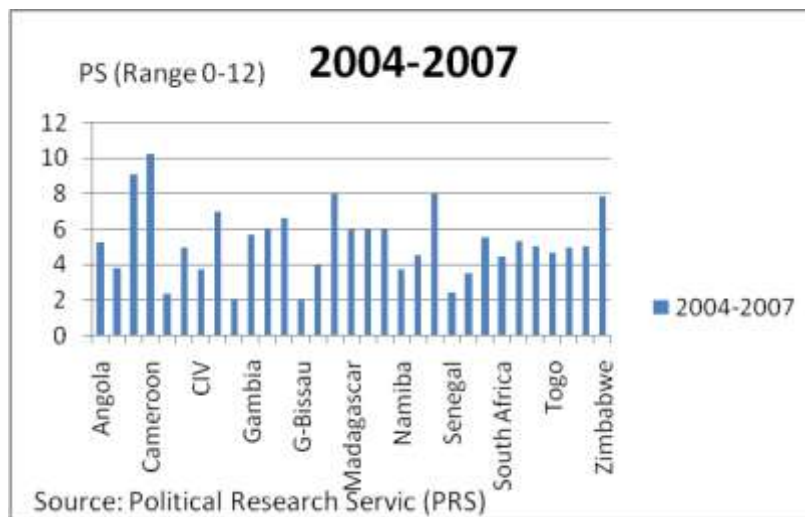
Data Source: Political Risk Service (PRS)

Figure 1.3. Political Stability for the Least Stable SSA Countries, 1984-2007



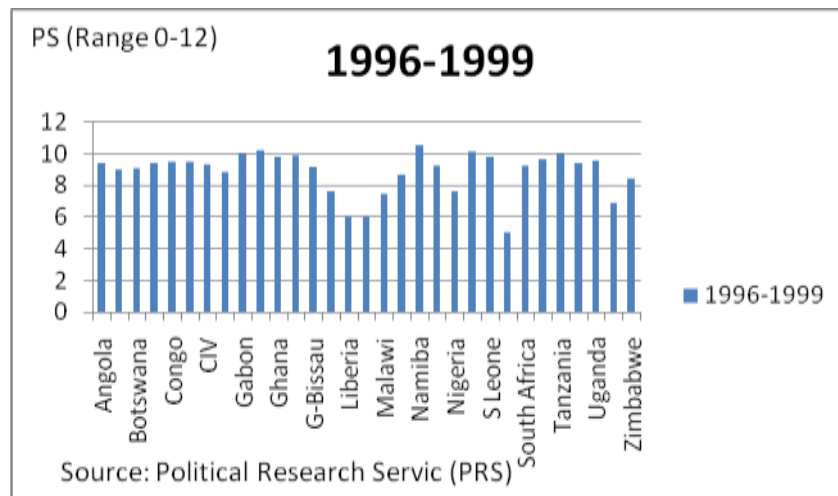
Data Source: Political Risk Service (PRS)

Figure 1.4. Political Stability for SSA Countries, 2004-2007



Data Source: Political Risk Service (PRS)

Figure 1.5. Political Stability for SSA Countries, 1996-1999



Data Source: Political Risk Service (PRS)

Figures 1.2-1.5 shows that the measure of PS is a credible measure of political conditions. For each country, there is variation in the PS measure over time, and for each period, there is variation across countries in the PS measure. Figures 1.2 and 1.3 demonstrate that there is variation over time in the measure of PS not only for the most stable SSA countries like Ghana, South Africa and Tanzania, who have average PS values greater than 6.8 (the mean PS), but also for the least stable SSA countries like Congo (DRC), Somalia and Liberia for which average PS is less than 6.8 or the mean PS. For both the least stable and the most stable set of countries (Figure 1.2 and 1.3), the high PS numbers are concentrated at the end of the data range, while the opposite holds true for the low PS numbers. This indicates a general rise in political stability of the SSA region more recently for the least stable countries and is consistent with observation. Further, the PS index values appear to correspond to perceptions of the political situation for the SSA countries over time. For example, Liberia has higher PS score for 2003-2007 than for 1996-1999, when it was still plagued by conflict and uncertainty. Figures 1.4 and 1.5 illustrate that for each year there is heterogeneity in the score of PS for SSA countries. Visual inspection of Figures 1.4 and 1.5 reveals that for the countries that are

neither the least stable nor the most unstable, political stability has declined from 1999-2007, but only very slightly.

## 1.5 METHODS

The empirical growth model in (1) is applied to thirty-one SSA countries from 1984-2007. Before estimating (1), the annual data were converted to four-year averages, because one-year intervals are too short to capture growth rates (Deaton, 2008).

The possibility that endogeneity bias may arise from different sources (simultaneity or unobserved effects), the small size of our sample, and the lack of valid instruments for the potentially endogenous aid and political stability variables posed peculiar econometric challenges for the estimation of the growth equation. A small sample size typically causes problems in estimation of the aid-growth relation because the traditional IV estimation techniques used to correct for endogeneity bias such as two-stage least square (2SLS) produce inconsistent estimates when the sample size is small (Woolridge, 2002). Further, Durbin-Wu-Hausman tests of endogeneity have low power in finite samples and may not detect endogeneity bias even when it is present. Even when the number of observations is sufficient, which would normally make traditional IV estimates consistent, traditional IV-type regressions are of little use in correcting endogeneity bias specifically in aid-growth regressions (Deaton, 2008). This is because in the context of SSA, none of the “standard” instruments for aid in the literature such as population (see BD, 2000 and Islam, 2005), and primary exports (see Bruckner, 2011) satisfies a major requirement for instrument validity: zero correlation between the instrument and the error term (exogeneity).

The aid-growth literature has paid even less attention to evaluating whether the “standard” set of instruments for aid is sufficiently strong. This may be because most of the significant contributions to the aid literature occurred in the twentieth century while the literature on weak instrument (see Stock and Yogo (2005)) emerged more recently. Further, when instruments are weak, IV estimation is inconsistent (Bound, Jaegger and Baker, 1993). We therefore drop instrumental variable (IV) analysis as a strategy for mitigating simultaneity bias.

Unobserved effects can be either time-varying or time invariant. Latent and time-invariant variables such as cultural norms and historical tensions that affect growth also affect aid, political stability and policy, so that unobserved effects may account for a considerable portion of the total endogeneity bias. Time-invariant unobserved effects can be removed by first differencing (FD). If such a strategy eliminates endogeneity bias we should notice corrected signs and stronger statistical significance of coefficients and better fit of the FD model relative to OLS. Further, we lag the endogenous variables so that they are predetermined in the aid equation to reduce the possibility of simultaneity. The structure of the first difference (FD) formulation of the OLS regressions in (1) – (3) are shown in (4) - (6)

$$(4) \quad \Delta GROWTH_{it} = \gamma_0 + \gamma_{AID} \Delta AID_{it-1} + \gamma_{SAID} \Delta AID_{it-1}^2 + \gamma_{PS} \Delta PS_{it-1} \\ + \gamma_{AIDPS} \Delta AIDPS_{it-1} + \Delta Z'_{it} \gamma_z + \Delta v_{it}$$

$$(5) \quad \beta_{FD} = (\Delta X' \Delta X)^{-1} \Delta X' \Delta Y$$

$$(6) \quad E(\varepsilon_{it} \varepsilon_{it}') = \sigma^2.$$

The observant reader will notice that as it stand the structure of (4) - (6) does provide detailed information about the time relationships in the data and makes the point that FD removes latent time invariant country-specific effects. However these equations (4) - (6) do not automatically account for possible bias due to unobserved but time-varying country-specific effects; a matter we take up again later in the paper.

Given sufficient data, GMM is the optimal estimation method because it treats both unobserved endogeneity and simultaneity endogeneity (Hansen and Tarp, 2001). However, although we did perform such GMM estimations in previous versions of this paper we do not rely on results of the GMM dynamic panel model because it is likely fraught with finite sample bias since our dataset is small. Our current strategy of lagging AID, PS and AIDPS and estimating by FD eliminates all the unobserved endogeneity and is the correct estimation method. Fixed-Effects (FE) is not applicable here, because the data is not strictly exogenous. Residual simultaneity may persist however despite lagging PS, AID and AIDPS. Islam (2005) and Burnside and Dollar (2000) treat simultaneity with IV and find no significant simultaneity bias since estimates of aid are the same as OLS in magnitude but Aguir (2011) using rainfall and primary exports as instruments for



aid concludes that simultaneity biases his estimates upwards in IV estimation. In comparison, Hansen and Tarp (2001) and Dalgard and Hansen (2003) both use GMM and find contrasting results. While the former notes differences between GMM and OLS estimates, the latter does not find any differences so the controversy about the effect of endogeneity (direction and size) persists in the literature.

## 1.6 DISCUSSION OF RESULTS

The empirical strategy was executed to (i) identify and quantify the effect of foreign aid on growth in SSA, (ii) to determine if political stability influences the aid-growth relationship, and (iii) to address any endogeneity problems that emerge. The main results of estimation of the growth relationships (1) are presented in Table 1.3.

Columns 1 and 2 of Table 1.3 display results of estimation of equation (1) respectively by OLS, and FD. In contrast, columns 3 and 4 contain the same regressions in columns 1 and 2 but with PS dropped to evaluate how important the influence of political stability is to the aid-growth relationship. Finally note that  $AID_{t-1}$ ,  $PS_{t-1}$  and  $AIDPS_{t-1}$  are lagged in the FD estimations (columns 2 and 4) but not in the OLS regressions (columns 1 and 3). This means for the FD estimations (but not the OLS regressions),  $AID_{t-1}$ ,  $PS_{t-1}$  and  $AIDPS_{t-1}$  are pre-determined in the growth regression so there is little simultaneity bias. OLS estimation was performed with both lagged and contemporaneous aid, political stability and their interactions ( $AID_t$ ,  $PS_t$  and  $AIDPS_t$ ) but results of only the contemporaneous variables are reported (as there is little difference between the two) to facilitate comparison of our OLS results with estimated coefficients of the aid-growth relationship in the literature. All regressions in Table 1.3 are corrected for serial correlation and heteroskedasticity using FGLS.

Table 1.3 Growth Regression Results

	(1)	(2)	(3)	(4)
	OLS	FD	OLS	FD
IGDP	-0.0001 (-1.15)	-0.003 (2.04)*	0.009 (-0.39)	-0.001 (0.97)
AID	12.05 (2.19)*	8.066 (2.62)*	0.232 (0.15)	5.775 (1.95)
PS	1.084 (4.12)***	1.593 (4.94)***		
PRIM	0.098 (0.22)	0.744 (0.25)	0.043 (0.09)	1.299 (0.45)
M <sub>2</sub>	0.049 (1.64)	0.106 (2.51)*	0.049 (1.39)	0.108 (1.92)
BQUAL	0.727 (1.61)	1.303 (1.98)*	0.583 (1.37)	0.99 (1.41)
DACC	0.253 (0.77)	1.535 (2.13)*	0.363 (1.1)	1.102 (1.51)
GCONS	-0.007 (-0.18)	-0.095 (-0.84)	-0.004 (-0.1)	-0.198 (1.44)
LE	0.013 (0.46)	0.184 (2.00)*	0.024 (0.76)	0.157 (1.69)
INVPROF	0.078 (0.3)	0.946 (1.5)	0.483 (2.56)*	0.025 (0.06)

	(1)	(2)	(3)	(4)
	OLS	FD	OLS	FD
AIDPS	0.872 (1.69)	0.332 (1.98)*		
STD_AID	-1.861 (-0.57)	-6.214 (-1.63)	2.415 (0.84)	-2.416 (-0.76)
Constant	-8.48 (2.29)*		-4.643 (-1.32)	
Observations	167	102	167	102
Adjusted R-squared	0.33	0.55	0.19	0.4

Note: Each regression included a set of time dummies. Errors are corrected for serial correlation and heteroskedasticity. The AID, PS and AIDPS variables are all lagged one period in the FD estimations. Three outliers identified in the text, were deleted in each regression. The square of AID and the time dummies are never significant and are not reported. Student t-statistics are in parentheses. Asterisks indicate level of significance: \*, \*\*, and \*\*\* reflect significance at the 10, 5, and 1 percent levels respectively.

The FD estimations appear to fit the data better than the OLS because their coherence measures such as t-values of individual coefficients are higher than the OLS values irrespective of whether political stability is in the equation or not. The major results of the research as presented in the different Columns of Table 1.3 are that AID and PS both positively impact growth in SSA and that political stability enhances the growth-stimulating powers of aid. This is because from Columns 1 and 2 of Table 1.3, aid, political stability and their interactions are positively related to growth at five percent significance level, respectively, by OLS and FD although the magnitude of the AID coefficient in the FD equation is smaller than in the OLS equation. Most importantly, since AIDPS, the interaction of aid and political stability is also significant (albeit at the 0.1 level), we conclude that conditional on stability aid promotes growth.

The reduction in magnitude of the coefficient on aid for the FD estimate may be explained by the difference in the level of endogeneity treatment that OLS and FD respectively provide. Omitted variable bias, which cannot be reduced by OLS, went down with FD, indicating that unobserved country-specific effects constitute the majority of any possible omitted variable bias. Any remaining bias has to be time-varying as FD removes all time-invariant sources of bias. Although we are able to remove the time-invariant unobserved effects by FD, endogeneity bias, albeit very limited, may still exist due to simultaneity despite lagging AID, AIDPS and PS.

We evaluated the possibility of endogeneity arising from simultaneity in earlier versions of the paper. In particular, we estimated the aid-growth equations by IV after re-specifying the model as a system of 4-simultaneous equations. Although first stage regression F-statistics and the Stock and Yogo (2005) test suggested the instruments were not very strong, we got very similar results in terms of the signs and magnitudes of the coefficients on ( $AID_{t-1}$ ,  $PS_{t-1}$  and  $AIDPS_{t-1}$ ) to the OLS so simultaneity does not appear to be an issue but unobserved effect endogeneity is an issue. The absence of potentially important time-varying factors from the list of regressors could also undermine the robustness of regression results but previous iterations of the paper using such time-varying factors as inflation or Burnside and Dollars' (2000) policy variable did not significantly influence the results.

For completeness, note that there may still be an endogeneity problem if there are unobserved time-varying country-specific characteristics that influence aid and growth. For example, some SSA countries may have different technologies of production, endowment, or institutions which can vary with time rendering FD estimation impotent at treating endogeneity. Angrist and Pischke (2009) point out that the notion that "the important omitted variables are time-constant is implausible." Simple first-differencing may not be effective in this case so the estimation method should also address the endogeneity caused by time-varying variables. To account for this issue, in earlier versions of the paper, we used the "random growth" specification (Papke, 1994) that allows for endogeneity to be based on country-specific growth rates. We interacted a trend variable with the country dummies in a LSDV specification to accomplish this. This did not change the OLS results much so it seems that the bias is mainly based on time-invariant variables. Finally, given that the sample size is small which compromised the strength of the instruments for aid in GMM and IV these estimation strategies offer no improvement over FD.

In comparison to results in columns 1 and 2, aid and political stability are insignificant in Columns 3 and 4 where political stability is omitted indicating political stability is an important pre-condition for aid. The majority of the coefficients of the other variables in our model have the expected sign in both OLS and FD estimations, where PS is included, although not many have statistically significant coefficients.

To determine the economic relevance of the aid-growth relationship in SSA, we compute the marginal effects (MEs) of growth with respect to aid. The MEs were calculated for the OLS and FD estimations in columns 1 and 2 of Table 1.3. We obtained a value of 0.12 for the ME of growth with respect to aid using OLS where aid is not lagged so that a one percent increase in aid will lead to a 0.12 percent increase in growth. In other words since AID is scaled by GDP, a \$1 increase in aid will lead to a \$0.12 increase in GDP. Further, we obtain a value of 0.084 for the same ME using FD where aid is lagged after taking the significant AIDPS in the FD regression into account. In comparison, Islam (2005) finds using OLS (and data from all LDCs not just SSA) a unit increase in aid as a fraction of GDP, increases growth by 0.12 percent for LDCs. This agrees with our results.

A potential concern about the robustness of the primary conclusions of the research that aid is more effective in more stable countries concerns the limitation of PS measure because it does not explicitly reflect corruption which can often be an overriding problem. However we did replace the PS measure with Transparency International's Corruption Perception Index (CPI) in previous estimations and arrived at the same conclusion because more corruption was associated with less growth. The result of the analysis should, however, be interpreted with care because about 30% of ODA aid is multi-lateral aid and the remaining 70% is bilateral aid although we used total ODA aid in the research. It is also worth noting, that the strategy of the new players in aid donation China and India (former recipients of aid) of providing aid to improve or build vital infrastructure in SSA (National Public Radio) may in the end yield better results than ODA which often does not focus on improving infrastructure in the recipient country.

#### 1.7 DECOMPOSITION OF THE EFFECTS OF POLITICAL STABILITY

To further decompose the effect of PS on the aid-growth relationship, we compute the aid-growth effect at different values of PS. From Figure 1.6, the marginal effect (ME) of aid on growth computed at the median of growth and aid is positive and rises very gradually at low levels of PS. Keeping in mind that the PS scale is from 0-12 with 12 being most stable, it can be seen that at very high levels of PS (higher than the mean and median of PS), ME rises precipitously. In fact, AID, AIDPS and PS are all weakly significant below a PS value of 6 at 5% significance level. At PS values greater than 6 (the median of PS), these variables are strongly significant at 5% significance level.

Figure 1.6 Partial Effects at Different Levels of Political Stability

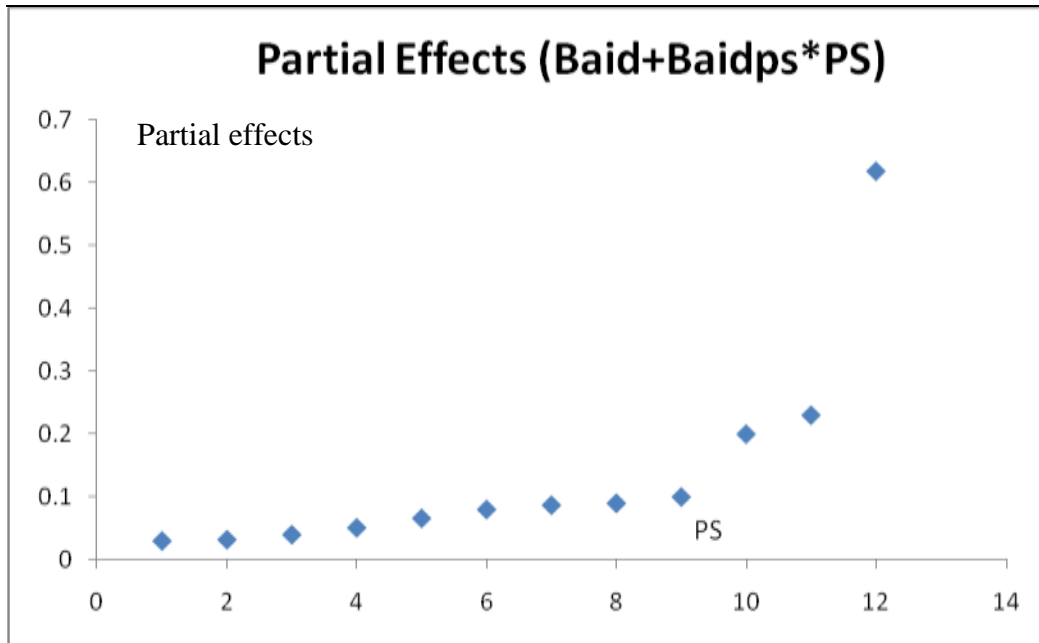


Figure 1.7 Elasticity at Different Levels of Political Stability

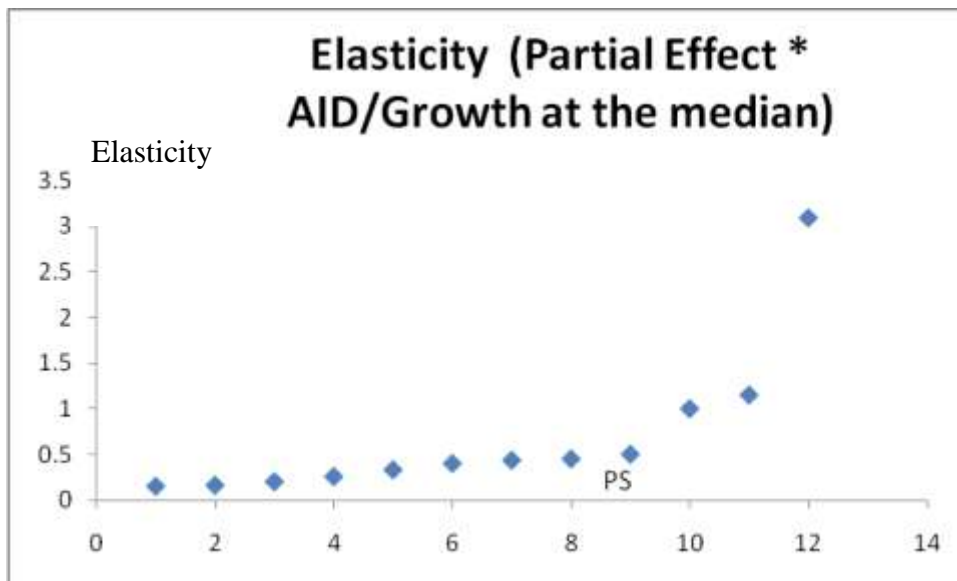


Figure 1.7, which plots the elasticity of growth with respect to aid against PS, substantiates the point made in figure 1.6 because it shows that growth is inelastic at low levels of PS but elastic at very high levels of PS. Beyond the relatively high PS value of

10, a one percent increase in aid leads to a greater than one percent increase in growth. However, the majority of poor SSA countries have PS values lower than 10 which might explain of why the effect of aid on growth is sometimes difficult to discern in SSA.

## 1.8 CONCLUSION

The research objective was to determine the sign and economic relevance of the relationship between aid and growth in SSA and further to investigate the consequence of political stability and economic policies on the aid-growth relationship. The evidence suggests that aid and growth are positively related at the five percent significance level, that political stability has a strong influence on the aid-growth relationship in SSA and that the aid-growth relationship suffers from endogeneity bias caused primarily by unobserved time-constant effects. Our results help to clarify why so much aid has done so little good in SSA. Aid is currently given independent of country stability. Based on our findings, aid is more effective at higher levels of stability so reaching the millennium development goals is more likely when aid is provided to stable SSA countries. Aid can prevent starvation in poor unstable SSA countries, but cannot be expected to spur growth there. A policy recommendation of this paper is that the pursuit of political stability and good governance in SSA is not only a worthy objective in itself, but also because stability promotes growth and augments the growth-promoting power of aid.

To make the principal results of this research that political stability makes aid more efficient at promoting growth-more meaningful, the determinants of political stability specifically in SSA are good candidates for further research. In particular it will be interesting to investigate how big a role a free press plays in the attainment of political stability.

Finally the literature could benefit from more detailed investigation in the issue of time-varying observed endogeneity. Angrist and Pischke (2009) suggest a way to check the robustness of estimation when there is the possibility of residual bias due to latent but time-varying country-specific effects. Their suggestion involves first performing an Arrelano and Bond (1991) or AB-type dynamic panel estimation. However, they note that this estimate may be inconsistent if the lagged dependent variables are not uncorrelated with the error term and thus are not appropriate instruments. To check

robustness, they suggest performing two separate regressions (a) with the lagged dependent variable but no country-specific dummies and (b) without time dummies but with country-specific dummies. Angrist and Pischke (2009) point out that if estimates of the slopes using AB-type estimation is statistically significant and its value is bracketed by the estimates from the regressions a and b, the time-varying endogeneity is not a significant issue. Despite Angrist and Pischke's (2009) suggestions, to the best of our knowledge effective methods of treating endogeneity caused by latent time-varying country-specific effects remain elusive.



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## ESSAY 2: ESTABLISHING THE FEASIBILITY OF USING THE COCOA FUTURES MARKET FOR RISK MANAGEMENT BY SUB-SAHARAN COCOA EXPORTERS

### 2.0 SUMMARY

Using recent New York Board of Trade (NYBOT) data, this paper investigates whether the cocoa futures market is unbiased and efficient using two and five-month forecast horizons. The presence of a time-varying (and or constant) risk premium is also assessed. Cash and futures prices are co-integrated and tests confirm market efficiency and unbiasedness in the long run. However, based on the necessary encompassing condition for efficiency, the cocoa futures market is biased and inefficient in the short run. Short-run bias is not due to a time-varying or constant risk premium, but rather to informational inefficiency. Out-of-sample analysis, however, suggests informational inefficiency is limited in magnitude and insufficient to generate economically relevant profits in the short run. This implies the cocoa futures market is short-run efficient by the sufficiency criterion. Overall, the finding of both long and short-run futures market efficiency suggests futures' hedging of cocoa export price risk is a feasible market-based risk management strategy for Sub-Saharan Africa's cocoa exporters.

*Keywords:* Cocoa, futures market, time-varying risk premium, and co-integration.

### 2.1 INTRODUCTION

Although cocoa futures markets provide price risk management opportunities for cocoa exporters in Sub-Saharan Africa (SSA), cocoa exporter participation in futures markets is low (Razzaque, Osafo-Kwaako, and Grynberg, 2007 and Morgan, 2001).

Reasons offered to explain the limited participation in futures markets by cocoa exporters include mistrust, ignorance, margin and transaction costs, and financial requirements (Thompson, 1986; Outtara, Schroeder and Sorenson, 1990). However, SSA cocoa exporters may limit the use of futures markets for hedging because they perceive that the cocoa futures markets produce biased and inefficient forecasts of cash prices (Sabuhoro and Larue, 1997). Biased and inefficient futures forecasts signal market failure and introduce additional costs in terms of sub-optimal hedging strategies (Thompson, 1986). Hedging may also involve other costs such as a risk premium (either time-varying or constant), making it less attractive.

The relatively recent failures of non-market methods of managing cocoa export price risk with buffer funds and buffer stocks have led to an increased demand for market-based price risk management strategies such as hedging among cocoa exporters (Larson, Verangis and Anderson, 2004; Just, Khantachavana and Just, 2010). Relevant questions that emerge for assessing the usefulness of market strategies for risk management include: (1) Does the cocoa futures market offer a precise indication of the subsequent period cash price? (2) Should cocoa exporters expect to pay a risk premium (time-varying or constant) to use the futures market? If the answers to these questions support efficiency and the absence of a risk premium, then futures forecasts are unbiased implying that risk hedging with futures is feasible and propitious for cocoa exporters.

Four of the world's preeminent cocoa exporters, Ghana, Cote d'Ivoire (CIV), Cameroun and Nigeria, are located in Sub-Saharan Africa and account for sixty-nine percent of total world cocoa beans exports (Gibson, 2007). Cocoa exportation from these SSA countries is typically done by sovereign cocoa marketing boards whose

governments rely heavily on volatile cocoa export revenue to fund economic development (Razzaque, Osafo-Kwaako, and Grynberg, 2007). Volatility in cocoa export prices induces risk both in the terms of trade (export price/import price) and export revenue. Elevated terms of trade and export revenue risk can undermine SSA's economic development because SSA's development is often export-driven (Rolfo, 1980). Since bias in futures markets reduces the accuracy of the forecast of the subsequent period cash price and undermines risk minimization through futures hedging, this paper tests whether the cocoa futures market is unbiased and efficient where unbiasedness is understood to be a joint hypothesis of risk neutrality and market efficiency (Beck, 1994).

A test of futures market unbiasedness and efficiency remains pertinent because (i) significant ambiguity still surrounds the unbiasedness and efficiency of the cocoa futures market with different authors arriving at contrasting conclusions and (ii) futures forecast bias remains a topical issue as evidenced by the allegations in July 2011 of manipulation of cocoa prices on the London International Financial and Futures Exchange (LIFFE) by cocoa merchants (Futuresmag.com, 2011). Here we clarify that the necessary condition for an efficient futures market is that current prices reflect all information implicit in price time series (Fama, 1970). In contrast, the sufficient condition for market efficiency is that no analyst can manipulate the market to make money (Fama, 1970).

Using in-sample data, cash and futures prices are found to be co-integrated; meaning cash and futures prices move together in the long run which is a necessary condition for long-run futures market efficiency. By comparison, the results of two different tests predicated on the necessary condition for efficiency indicate that the cocoa futures market is biased and inefficient in the short-run. The first test involved tests of

parameter restrictions on the Error Correction Model (ECM) while the second test used was Sanders and Manfredo's (2005) modification of Harvey, Leybourne, and Newbold's (1998) test of forecast encompassing. Short-run bias is found to be due to informational inefficiency not to a risk premium.

To verify the in-sample results (following Diebold and Nason (1990) and McKenzie and Holt (2002)), out-of-sample analysis were performed which revealed that the cocoa futures market is short-run efficient by the sufficient condition of efficiency as it is difficult to generate economically relevant profits. The finding of both short and long-run futures market efficiency by the sufficiency criterion suggests futures' hedging of cocoa revenue risk is a feasible market-based risk management strategy for SSA's cocoa exporters.

## 2.2 LITERATURE REVIEW

Beck (1994), Subahuro and Larue (1997), and Manayi and Struthers (1997) all tested for unbiasedness and efficiency of the cocoa futures market and attempted to identify a constant (but not time-varying) risk premium in the cocoa futures market. Notably, they arrive at opposite conclusions, indicating that significant ambiguity still surrounds cocoa futures efficiency and unbiasedness. Further, since the available literature uses data that are somewhat dated, existing research results regarding cocoa futures market inefficiency and bias may no longer be relevant for current decisions.

Beck (1994) rejects the efficiency and unbiasedness of the cocoa futures market and the hypothesis of a constant risk premium in cocoa futures markets. She uses NYBOT data from 1966 to 1986 and employs co-integration techniques to evaluate cocoa



market inefficiency and bias. Beck (1994) performs her analysis for 8-week (2-month) and 24-week (6-month) forecast horizons. For the 8-week horizon forecast, Beck pools data from five cocoa futures contracts. The cash price used is the expiration day futures price and the corresponding futures forecast price is the futures price recorded 8 weeks prior to expiration. By contrast, data from only one contract was used for the longer 24-week forecast horizon, although the cash price is still the futures price at expiration. Beck (1994) ascribes cocoa futures forecast bias to informational inefficiency, which is the inability of the cocoa futures market to incorporate all available information to produce unbiased forecasts of the subsequent cash prices and not to the presence of a risk premium in cocoa futures. Beck (1994) only considers a constant risk premium and does not allow for the possibility of a time-varying risk premium.

Sabuhoro and Larue's (1997) disagree that a bias exists in the cocoa futures market. They employ Johansen and Juselius' co-integration tests, Hansen (1992)'s test of the stability of co-integration parameters, and an error correction model (ECM) to test for cocoa futures market inefficiency and bias. Sabuhoro and Larue (1997) used daily cash and futures data for contracts with maturities of two and six months from the Coffee, Sugar, and Cocoa Exchange (CSCE) from 1983 to 1990. They conclude that the futures market is unbiased and efficient and that there is no risk premium. However, Sabuhoro and Larue (1997)'s use of cash and futures data that terminated in 1990 calls into question the applicability of their results to contemporary hedging decisions.

Manayi and Struthers (1997) test for cointegration between cocoa spot and futures prices. They also test for futures market efficiency and unbiasedness. They use monthly spot and futures data from the London International Financial Futures and Options

Exchange (LIFFE) from 1985 to 1991, different cointegration tests, and a GARCH (1, 1) in mean model to ascertain futures market efficiency and bias. They conclude that cocoa cash and futures prices are not co-integrated, and the cocoa futures market is biased and inefficient and exhibits a positive risk premium. Specifically, they argue that for non-stationary data, co-integration is a necessary albeit insufficient condition for futures market efficiency and unbiasedness. However, since they find that the cocoa cash and futures prices are non-stationary but not co-integrated, they conclude the cocoa futures market is long-run biased and inefficient. They assert that the cocoa futures market is “informationally inefficient” in the short run and that short-run profitable opportunities exist for speculators in the cocoa futures market. Manayi and Struthers, however, indicate that the GARCH specifications they employed were restrictive, because the GARCH terms were insignificant while the ARCH (1) coefficient in the mean equation was significant. They suggest the use of ARCH type model to test for a risk premium.

The conclusions of the various studies testing for cocoa futures market efficiency and for risk premiums vary and are often contradictory. This occurs because of subtle differences (i) in the research methods used, (ii) in the range, construction and origin of the futures series used by the different authors and (iii) because the authors differ in how much care they devote to testing for structural breaks, stationarity, cointegration, and market efficiency.

To illustrate, a difference in the data and methods employed is that Subahuro and Larue (1997) pooled data from different contracts in building the futures data series--their research therefore suffered from the overlapping horizon problem--but Beck (1994) does not pool data from different futures contracts. Further, Beck (1994) assumed a constant

risk premium in testing for market efficiency but Sabuhoro and Larue (1997) ignore the existence of a risk premium. Sabuhoro and Larue (1997) do not assume cointegration is equivalent to long-run market efficiency but test separately for long-run market efficiency and unbiasedness. In contrast, Beck (1994) assumes cointegration is equivalent to long-run market efficiency and so only focuses on testing for cointegration.

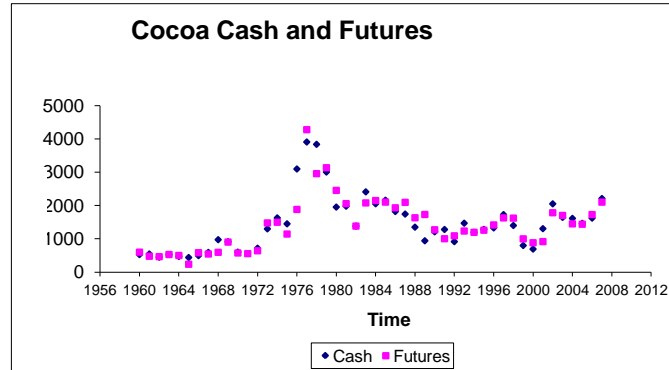
A difference in the data ranges used by the different authors is illustrated by the fact that although the futures data employed by both Beck (1994) and Subahuro and Larue (1997) came from the NBYOT, Beck (1994) used data from 1966 to 1986 while Subahuro and Larue (1997) employed data from 1983-1990. Market efficiency might be dependent on the range of data used (Beck, 1994; Elam and Dixon, 1988). In particular, structural breaks occurring in one particular price range but not the other may result in differences in the data generation process of the prices in the different ranges which make it difficult to accurately determine efficiency.

Unlike Beck (1994) and Subahuro and Larue (1997) who use data from the NYBOT, Manayi and Struthers (1997) used data from the London FOX. Given the differences in methods, range and origin of the data used, the contrasting conclusions regarding market efficiency and unbiasedness is perhaps not so strange.

Interestingly however, none of the previous authors test for a structural break in the data as we do here although structural breaks can undermine the validity of tests of unit roots and hence of cointegration and market efficiency. In particular, in testing for a unit root, a structural break that is neither detected, nor accounted for, will yield biased or incorrect results of tests of stationarity (Frank and Garcia, 2009). Given a suggestive

break in the data for the current data (see Figure 2.1), we test for a structural break prior to conducting tests of stationarity and market efficiency.

Figure 2.1 Evidence of a Structural Break in 1978 in Cash and Futures Prices (\$/ton)



Source: NYBOT

We contribute to the literature by assessing the efficiency of the cocoa futures market using both the necessary and sufficient conditions for market efficiency while taking the time series properties of the cash and futures data into account.

## 2.3 DATA AND METHODS

Futures price data from 1980-2008 were obtained from the New York Board of Trade (NYBOT) which has an active and liquid cocoa market. As is typical in this literature, the analysis employs both a long horizon which is the relevant horizon (five-months) for hedgers but has few observations, as well as a shorter horizon (two-months) which is less relevant but has more observations. Pragmatically, SSA cocoa exporters may place a hedge in the pre-harvest period (July) for protection against price fluctuations during harvest (December), a five-month hedge horizon. The main cocoa harvest season is from November to January with peak harvest in December. Pre-harvest

is from February to October (COCOBOD, 2000), so it is possible to have different hedge horizons, but for simplicity we focus on the five-month July-December hedge.

Presently few SSA exporters hedge their risk with the cocoa futures market. The hedgers in the current cocoa futures market are cocoa buyers such as cocoa processors, chocolate manufacturers and merchants who deal in cocoa beans, while speculators who provide liquidity include small and large investors (Dand, 1999). Unlike most SSA cocoa exporters who have little experience hedging price risk with futures markets, current market participants have extensive experience in using the futures markets and have elaborate research divisions to analyze price movements and to make hedging decisions (Dand, 1999). For the existing hedgers, a hedge horizon of two-months is sufficient, since they constantly use cocoa beans and require protection against price fluctuation over both short and long horizons. For SSA cocoa producers not now hedging but who may consider placing pre-harvest to harvest hedges, however, longer five-month horizons are more meaningful.

Statistically it is not feasible to test for short-run futures market unbiasedness with a five-month horizon while avoiding the overlapping horizons problem, because this will result in very few observations leading to unreliable results. Futures forecast bias may emanate either from a (time-varying) risk premium or from informational inefficiency although the decomposition of the bias is seldom straightforward (Frank and Garcia, 2009). ARCH-type models used to test for the presence of a time-varying risk premium in the short-run require high frequency data usually available with short-horizon data. Longer forecast horizons (5-months) result in low frequency data that smooth time series data. Smoothed time series data mask the ARCH-effects that are indicative of a time-

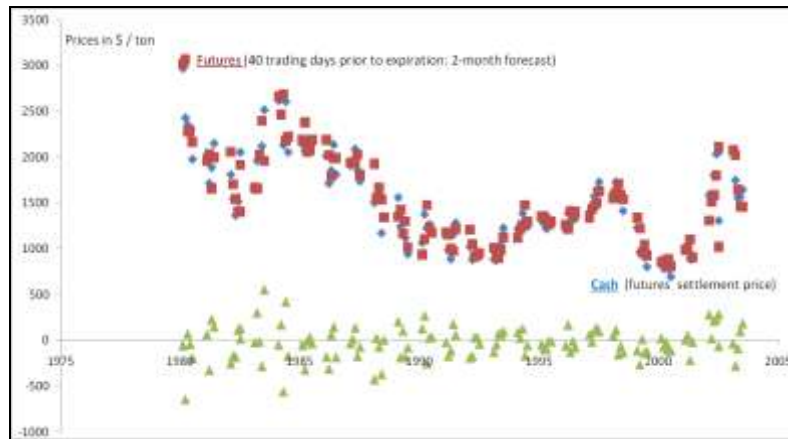
varying risk premium compromising tests for a short-run time-varying risk premium and hence for short-run unbiasedness (Frank and Garcia, 2009).

We follow the compromise in the literature (See Beck, 1994 and Subahuro and Larue, 1997) and test for market efficiency and for a time-varying risk premium in the short run exclusively with a two-month horizon and for long-run market efficiency with both a short horizon (two-month) and a longer (five-month) horizon. Subahuro and Larue (1997) also use two and six-month forecast horizons in order to determine if tests for long and short-run market efficiency yielded consistent results irrespective of the duration of the forecast horizon. However, their analysis suffered from the problem of overlapping horizons because they pooled data from different contracts. Overlapping data may lead to an overstatement of information content in prices and can distort standard errors. Further, the time span for their analysis was relatively short (1983 to 1990). We use a longer time period (1980-2008), only the December contract and a five-month instead of a six-month horizon because the former is more relevant for SSA cocoa exporters' hedging decisions.

The data for both the two and five-month horizons span from 1980 to 2008, but to test for short run unbiasedness and evaluate out-of-sample forecast accuracy with a sufficient number of observations, we divide the two-month horizon data into an in-sample period, 1980.1-2003.5, and an out of-sample period, 2004.1-2008.1. The dates refer to the year and the five futures contract maturity months: March, May, July, September and December. For instance, 2004.1 refer to the March maturity of 2004. The futures price used is the settlement price for a specific trading day. At expiration, this price is the forecast of the subsequent cash price. Theoretically, at expiration, the futures price is equal to the spot price except for a transactions cost band because arbitrage drives

them together (Beck, 1994). In practice, the expiration date futures price is often used instead of the spot price, because the latter is seldom available for the same grade and location of the commodity (Beck, 1994; Frank and Garcia, 2009). Figure 2.2 below plots of the futures and price cash price data used in this research over the relevant data range.

Figure 2.2 New York Board of Trade (NYBOT) Cocoa Cash and Futures: 1980.1-2003.5



The cones in the lower part of the figure are forecast errors.

A two-month horizon coincides with the highest level of futures trading activity in terms of both volume and open interest. Further, the probability of rejecting the null hypothesis of futures market efficiency and unbiasedness increases as the forecast horizon increases (Subahuro and Larue, 1997). A rejection of the null of futures market efficiency and unbiasedness is therefore a more powerful result the shorter the forecast horizon (Subahuro and Larue, 1997).

For the two-month horizon, we count back two-months from expiration (40 business days), and use the futures settlement price as the two-month forecast. Since there are five futures contract months for cocoa, there are five observations per year for

the two-month horizon yielding a total of 120 observations for the in-sample period (1980.1-2005.5) and 21 observations in the out-of-sample period (2004.1 to 2008.1). The NYBOT cocoa contracts do not expire every other month so it is impossible to build a dataset with equal forecast horizons and spacing. Following McKenzie and Holt (2002), Beck (1994), and Frank and Garcia (2009), a longer forecast horizon in December (approximately 60 days) was used for the two-month horizon.

For the five-month horizon, we count back five months from expiration (100 business days), and use the futures settlement price as the five-month forecast. The five-month horizon yields only one observation per year because only the December contract is used, which limits data severely, especially for testing for a short-run risk premium and for short-run market unbiasedness. Using the five-month forecast horizon yields only 28 observations (1980-2008). Consequently, low power unit roots and cointegration tests become less meaningful and time-varying risk premiums cannot be identified because the (Q) ARCH-type and (Q) GARCH-type models that are typically employed to identify a time-varying risk premium need considerably more higher frequency data. By comparing the results of the five-month horizon to the two-month horizon which has more data we are able to trade pragmatism (the relevant and longer horizon and limited data) with feasibility (the shorter horizon with more data) in order to draw inference regarding futures market bias, efficiency and the presence of a time-varying risk premium in the futures market.

## 2.4 PROCEDURES

### *Structural break and Unit Root Tests*



The choice of an appropriate model for analysis depends on the characteristics of the data. It is thus essential to verify the degree of integration of both the cash and futures price data, because the use of ordinary least squares (OLS) regressions on non-stationary data yields spurious results (Granger and Newbold, 1974). Furthermore, the results of standard tests of stationarity such as the Augmented Dickey Fuller (ADF) test can be influenced by structural breaks. When structural breaks are not properly accounted for in testing for unit roots, there is a higher likelihood of drawing incorrect conclusions regarding the stationarity of the data (Perron, 1989). The Zivot and Andrews (1992) test or the ZA test can be used to assess possible structural break points. The null hypothesis in the ZA test is that the variable contains a unit-root with a drift that excludes any structural break. The alternative hypothesis is that the series is a trend stationary process with a one-time break in the trend variable occurring at an unknown point in time.

The Augmented Dickey-Fuller (1979) (or the ADF test) and the Kwiatkowski, Phillips, Schmidt and Shin (1992) or the KPSS test are typically used to test for stationarity because they complement each other as they have opposite null hypotheses. While the null hypothesis of the ADF test is the presence of a unit root, the null hypothesis of the KPSS test is the absence of a unit root. Three distinct models were accounted for in executing the ADF test: with constant only, with constant and trend and with no constant and no trend, while incorporating lags ranging from 1 to 5. We use 5 lags to reflect the 5 contract months for cocoa futures. The Akaike Information Criterion (AIC) was used to determine lag structure (Enders, 2004). If the cash and futures prices are both non-stationary, it is possible that they are co-integrated (Enders, 2004). If the spot and futures prices are co-integrated, then the futures market is likely to be efficient

in the long run because identical factors determine both the spot and futures prices, so they should not diverge from each other (Beck, 1994). When futures prices are co-integrated, an ECM which simultaneously captures short- and long-run effects can be defined and estimated (McKenzie and Holt, 2002 and Beck, 1994). Given co-integration of cash and futures prices, the sufficient conditions for long-run unbiasedness are restrictions on the error correction mechanism between futures and future spot prices (Subahuro and Larue, 1997).

For non-stationary cash and futures prices, co-integration is a necessary albeit insufficient condition for futures market efficiency in the long run (Manayi and Struthers, 1997). To test for a co-integration relationship between cash and futures prices, either the Engle-Granger two-step or Johansen (1988)'s test can be used. Once cointegration is established there are several ways to test for long-run market efficiency and unbiasedness. Two of the main methods usually employed are (1) Johansen's method, which imposes likelihood ratio restrictions on the co-integrating vector in a (Vector) Error Correction ((V)ECM) framework, and (2) Davidson and Mackinnon's (1981) non-nested J-type test, which discriminates between the restricted ECM with the (0, 1) futures market efficiency and unbiasedness restriction imposed and the unrestricted ECM. The latter test is executed within the Engle and Granger framework. An advantage of the second test over the more commonly used Johansen test of LR restrictions in verifying market unbiasedness and efficiency is that it does not assume that the conditional variance is constant. When the variance of the error of the ECM is non-constant and the form of the conditional variance can be modeled, this test of market efficiency can be modified to incorporate the form of the conditional variance.

### *Model Selection and Long-Run Tests*

Model selection is complicated, because unbiasedness and efficiency of the futures market have a temporal dimension: the market could be biased (or not), inefficient (or not) either in the long or short run. Further, there may be a risk premium which may be time-varying or constant in the long run or the short run.

Let's begin with the notion that arbitrage usually forces current futures price to equal the expected future cash price for the same commodity at contract maturity (McKenzie and Holt, 2002). This is illustrated in equation (1) below:

$$(1) E_{t-1}S_t = F_{t-1}$$

where  $E_{t-1}S_t$  is the expectation of the current cash price conditional on information available in the previous period, and  $F_{t-1}$  is the price of the futures contract that will mature in period  $t$ . Assuming a linear rational expectations framework, (1) can be rewritten as (2):

$$(2) S_t = \alpha_0 + \alpha_1 F_{t-1} + \mu_t$$

where  $S_t$  in (2) is a non-stationary series and  $\mu_t$  is the error term. Given the specification in (2), the joint hypothesis of long-run market efficiency and unbiasedness is given by  $H_0: \alpha_0 = 0$  and  $\alpha_1 = 1$ .

When  $S_t$  and  $F_{t-1}$  in (2) are non-stationary, we can define a first difference version of (2) to make it stationary. This is achieved in (3):

$$(3) \Delta S_t = \alpha_1 \Delta F_{t-1} + \Delta \mu_t$$

where  $\Delta$  in (3) is the first difference operator, such that  $\Delta S_t = S_t - S_{t-1}$ . However, the transformation in (3) is mis-specified when the cash and futures prices are co-integrated (McKenzie and Holt, 2002). When the cash and futures prices are co-integrated, an ECM

must be estimated to account for the long-run equilibrium relationship between the respective cash and futures series. The structure of the ECM is given as:

$$(4) \Delta S_t = m - \rho \mu_{t-1} + \psi_1 \Delta F_{t-1} + \sum_{i=1}^I \Omega_i \Delta S_{t-i} + \sum_{j=2}^J \psi_j \Delta F_{t-j} + \Phi_3 D_3 + \Phi_5 D_5 + \Phi_7 D_7 + \Phi_9 D_9 + \mu_t \quad \text{where } \mu_t | \mu_{t-q} \sim N(0, \sigma_t^2),$$

$m$  is a constant term,  $\mu_{t-1} = S_{t-1} - \alpha_0 - \alpha_1 F_{t-2}$  is the stationary error correction term,  $D_i$  is a vector of dummy variables such that  $D_3, D_5, D_7, D_9$  and  $D_{12}$  are dummies for March, May, July and September, and take a value of one if the data are from the corresponding month and zero otherwise.  $D_{12}$  is omitted to avoid singularity. The magnitude of the estimated coefficient on the error correction term ( $\rho$ ) indicates the speed of adjustment of any disequilibrium towards the long-run equilibrium state (McKenzie and Holt, 2002; and Beck, 1994).

To implement the Davidson and MacKinnon J-type test of long-run market efficiency previously described, the (0, 1) futures market efficiency and unbiasedness restrictions on the cointegrating vector are imposed as in (5)

$$(5) \Delta S_t = n - \rho(S_{t-1} - F_{t-2}) + \psi_1 \Delta F_{t-1} + \sum_{j=2}^J \psi_j \Delta F_{t-j} + \sum_{i=1}^I \Omega_i \Delta S_{t-i} + \Phi_3 D_3 + \Phi_5 D_5 + \Phi_7 D_7 + \Phi_9 D_9 + \mu_t$$

where  $n = m + \rho \alpha_0$  is a constant and  $S_{t-1} - \alpha_0 - \alpha_1 F_{t-2}$  has been substituted for  $\mu_{t-1}$ , the error correction term in (4). The non-nested J-tests of Davidson and MacKinnon (1981) discriminate between the ECM with and without the (0, 1) cointegrating vector imposed. If the latter model (5) is preferred to the former (4), or if both are judged equivalent, the null of (0, 1) cointegrating vector cannot be rejected. The J-statistic typically has a t-distribution with  $n-1$  degrees of freedom. P-values that represent the probabilities of

falsely rejecting the null hypothesis are typically provided to help interpret the test results. The interested reader is referred to Subahuro and Larue (1997) and Davidson and MacKinnon (1981) for more details of this test.

When the variance of the error of the ECM is non-constant and the form of the conditional variance can be modeled, this test of market efficiency can be modified to incorporate the form of the conditional variance. For example, if there is a positive ARCH-p term in the error of the ECM that contributes to a time-varying risk premium, then the test of long-run market efficiency must discriminate between an ARCH-M-p-ECM with and without the (0, 1) market efficiency restriction imposed. Note that there is nothing within the structure of the ECM that prevents  $\sigma_t^2$  or the unconditional variance from varying, so the ECM cannot be used to identify time-varying risk premiums. However by testing for (Q) ARCH and (Q) GARCH effects in the error of the ECM, the correct form of the conditional variance can be identified so that the appropriate (Q) ARCH-p-M-ECM model can be applied. Correct modeling of the conditional variance is important for testing for a time-varying risk premium, for testing for market inefficiency and for supporting accurate statistical inference. It is also important to determine the appropriate number of lags of cash and futures prices to incorporate into (4). However, economic theory provides little guidance on the correct number of lags of the cash and futures price to include in (4). Economic theory is also not forthcoming regarding the structure of the conditional variance term in (4). To decide on the number of lags of the futures and cash prices to include in (4), we minimize the AIC for lags one to five after adding both cash and futures prices to the first difference specification in (3). The results

of the empirics dictate the addition of just one lag of the first difference of the cash price to the ECM so the actual form of the ECM in (4) estimated is given in (6) is:

$$(6) \Delta S_t = \alpha_0 - \rho \mu_{t-1} - \psi_1 \Delta F_{t-1} + \Omega_1 \Delta S_{t-1} + \Phi_3 D_3 + \Phi_5 D_5 + \Phi_7 D_7 + \Phi_9 D_9 + \Delta \mu_t$$

where all variables in (6) are previously defined.

To determine the presence and form of the conditional volatility in the cash equation, we performed both LM ARCH and QARCH tests. The LM ARCH test involves regressing the squared OLS residual from (6) on an intercept and the lagged residuals of (6). The test statistic (the sample size (N) \* R<sup>2</sup>) has a chi-square distribution with degrees of freedom equal to the number of lags, p,  $NR^2 \sim \chi^2_p$ . LM QARCH tests are performed by regressing the squared OLS residual on an intercept, the lagged residuals and the cross products of residuals of lags of different lengths. The test statistic has a  $\chi^2$  distribution with p(p+3)/2 degrees of freedom (Sentana, 1995).

Although the ECM in (6) is correctly specified to test the long-run unbiasedness conditions, it assumes a constant variance and so by construction it cannot adequately identify a time-varying risk premium in cocoa futures. This is because a risk premium is a reflection of the underlying uncertainty in the market which changes with time, and so the variance also changes with time because it is a measure of the risk premium. As it stands, the ECM cannot capture changes in the underlying uncertainties in the market because changes in the variance are not reflected in the model; An ECM-M model is needed. Furthermore, if LM ARCH and QARCH tests performed on the error of the ECM identify an ARCH or QARCH term, then a (Q) ARCH-p-M-ECM (p = 1,2,3..) instead of the ECM is appropriate for testing for a time-varying risk premium, futures market unbiasedness and efficiency. We employ a form of McKenzie and Holt (2002)'s

QGARCH-p-M-ECM model and methodology to pinpoint the source of short-run futures market efficiency and bias for a time-varying risk premium. Specifically, we use an ARCH-p-M-ECM ( $p = 1, 2, 3, \dots$ ) not a (Q) GARCH-p-M-ECM to test for market efficiency and bias and to identify a time-varying risk premium because no GARCH effects were identified.

The structure of the general ARCH-p-M-ECM is:

$$(7) \Delta S_t = m - \rho \mu_{t-1} + \psi_1 \Delta F_{t-1} + \theta \sigma_t + \sum_{i=1}^I \Omega_i \Delta S_{t-i} + \sum_{j=2}^J \psi_j \Delta F_{t-j} + \Phi_3 D_3 + \Phi_5 D_5 + \Phi_7 D_7 + \Phi_9 D_9 + \mu_t \text{ where } \mu_t | \mu_{t-q} \sim N(0, \sigma_t^2).$$

The conditional variance is specified as:

$$(8) \sigma_t^2 = \pi_0 + \sum_{q=1}^Q \pi_{qq} \mu_{t-q}^2 \text{ and } \pi_0, \pi_{qq} > 0, \sum \pi_{qq} < 1.$$

For meaningful results the magnitude of  $\rho$  must differ from zero because spot price changes respond to deviations from long-run equilibrium. Further,  $\psi_1$  must be non-zero since changes in the futures forecast price are incorporated in the current spot price (McKenzie and Holt, 2002). Note also that  $\sigma_t$  is a measure of volatility, the standard deviation, of  $\mu_t$  while  $\pi_0$ ,  $\pi_q$ , and  $\pi_{qq}$  are estimated coefficients of the variance so must be necessarily non-negative.

#### *Unbiasedness, Market Efficiency and the Risk premium Hypothesis in the Short-Run*

Failure to reject the null hypothesis of long-run futures market efficiency and unbiasedness ( $\alpha_0 = 0$ ;  $\alpha_1 = 1$  in (2)) implies tests of short-run market efficiency and unbiasedness may be identical concepts. Note that the tests of short-run market efficiency and unbiasedness employed in this paper were formulated and first applied by

McKenzie and Holt (2002). In this formulation if  $\alpha_0 = 0$ , there is no constant long-run risk premium therefore a short-run constant risk premium is also unlikely. If a short-run risk premium exists, it is likely to be time-varying. We will return to this issue later. If markets are long-run unbiased, however, we can jointly test for short-run market efficiency and bias with tests derived by McKenzie and Holt (2002) using the ECM. Following McKenzie and Holt (2002) short-run market efficiency implies

$$(9) \quad \text{Hypothesis 1: } \rho = 1; \rho\alpha_1 = \psi_1 \neq 0; \Omega_i = \psi_j = 0$$

where  $\psi_1$ , the coefficient associated with last period's change in the futures price, is nonzero because new information that affects the futures price also affects the impending spot price change (McKenzie and Holt, 2002).  $\Omega_i = \psi_j = 0$  arises since these lagged cash and futures prices should not affect the current price. If these short-run restrictions fail to hold, past futures and spot prices would contain relevant information not completely incorporated in the t-1 futures price that can be used to forecast the period t cash price, violating informational efficiency in the short run. In efficient markets, all past information is already incorporated in the t-1 futures price; therefore, the lagged futures price should have no effect on current spot price (Fama, 1970). As explained by MH (2002), the logic behind the restrictions  $\rho = 1; \rho\alpha_1 = \psi_1 \neq 0; \Omega_i = \psi_j = 0$  can be understood by rewriting (6) as:

$$(6') S_t = (1-\rho) S_{t-1} + \psi_1 F_{t-1} + (\rho\alpha_1 - \psi_1) F_{t-2} + \rho\alpha_1 + \Phi_3 D_3 + \Phi_5 D_5 + \Phi_7 D_7 + \Phi_9 D_9 + \Delta\mu_t$$

where  $S_{t-1} - \alpha_0 - \alpha_1 F_{t-2}$  has been substituted for  $\mu_{t-1}$ , the error correction term. Note that it is possible to have a short-run efficient but biased futures forecast so the risk premium and its constituent sources of inefficiencies need not be non-zero to test for short-run efficiency.

By comparison, short-run unbiasedness holds if the restrictions in (10) apply:



$$(10) \quad \text{Hypothesis 2: } \rho = 1; \psi_1 = 1; \Omega_i = \psi_j = 0; m = 0, \theta = 0 \text{ and } \Pi_i = 0.$$

The restriction  $\theta = \Pi_i = 0$  holds because an unbiased forecast cannot be inefficient thus variances and covariances of different lags of cash should not affect the current price. Similarly,  $\theta$  should be zero because a non-zero time-varying risk premium will imply a biased forecast. Notice that if the non-linear restrictions in (9) do not hold, then short-run futures market efficiency will be compromised because past futures and spot prices would contain relevant information not completely incorporated in the  $t - 1$  futures price but which could be used to forecast the current spot price (MH, 2002). However, if (10) does not hold then the futures market is short-run biased. In comparison, the sufficient condition for identifying a time-varying risk premium ( $\theta$ ) is the rejection of the null in hypothesis 3.

$$(11) \quad \text{Hypothesis 3: } H_0: \theta = 0.$$

If the long run tests of efficiency identify a zero constant risk premium then the short-run risk premium will also be constant. In that case, identification of a short-run time-varying risk premium is evidence that at least some of any bias in futures markets is due to a risk premium. However, the sign of  $\theta$ , the coefficient on  $\sigma_t$ , can only be determined empirically (Frank and Garcia, 2009). If  $\theta$  is positive, then the market is experiencing normal backwardation where the market is dominated by short hedgers who pay a risk premium to long speculators to bear the spot price risk. On the other hand, if  $\theta$  is negative then the market is under conditions of contango where the market is dominated by long hedgers paying a risk premium to short speculators (Keynes, 1930). If  $\theta$  is statistically insignificant, a time-varying risk premium does not exist in the cocoa futures market in either the long-run or the short-run.

Suppose the null hypothesis of a short-run time-varying risk premium is rejected, then short-run bias in futures market forecast of subsequent period cash prices is due to informational inefficiency. This is because in the context of the ARCH-M-p-ECM in (7), the time-varying risk premium  $\theta$  is represented by a conditional variance with a time-varying risk component. A finding that  $\theta$  is insignificant indicates that there is no time-varying or constant risk premium in the cocoa futures market in the short run so that any futures bias is due to informational inefficiency. This is obviously the case if long run tests performed already established a zero constant risk premium, so that there is little likelihood of a constant risk premium in the short run.

Tests we conducted for Q (ARCH) and ARCH effects identified the presence of an ARCH-3; therefore, we initially use both the ECM and the ARCH-3-M-ECM model for testing for short run market efficiency, bias and for a risk premium. As the results section will show we however focused on the ECM results based on evidence undermining the validity of the ARCH-3-M-ECM.

## 2.5 RESULTS

The ZA test fails to reject the null hypothesis of a unit root with no structural breaks for the levels of cash and futures prices using both two and five-month maturities. The critical values of the ZA test exceed the ZA test-statistic values for the levels of both cash and futures prices. For the two-month-horizon, p-values of 0.056 and 0.06 are obtained, respectively, for the levels of the cash and futures where the ZA critical value is -5.08. For the five-month horizon, p-values of 0.07 and 0.065 are obtained, respectively, for the levels of the cash and futures given the same critical value. Since the null

hypothesis of a unit root cannot be rejected, the alternate hypothesis of a stationary series with a one-time structural break does not hold.

The ZA test provides no evidence of a structural break in the cash and futures prices for the two- and five-month month forecast horizons. Plots of the cash and futures data and futures forecast error in Figure 2 confirm visually the absence of breaks in the data for the two-month horizon. The results of ADF and the KPSS tests of stationarity indicate that the cash and futures price are cointegrated for both the two-month and five-month forecast horizons. Futures and cash prices are integrated of order one, while the error of the regression of the levels of the cash on futures is stationary (integrated of order zero) for both two- and five-month horizons. To provide some detail for the tests, for the two-month horizon, the p-values for the ADF test for the levels and first difference of the cash prices are 0.077 and 0.045. The p-values for the ADF test for the levels and first difference of futures prices are 0.08 and 0.049 and the p-values for the ADF test for the error of the regression of the levels of cash on the levels of futures is 0.046. The corresponding statistics for the five-month horizon are respectively: 0.08, 0.07, 0.09, 0.056 and 0.06 also indicating cash and futures are cointegrated because both cash and futures have unit roots but the error from the regression of cash on futures is white noise. The five percent critical value of -2.88 used for comparison with test statistic values is due to Engle and Granger (1987) and was obtained from Enders (2004).

For both two- and five-month horizons, the KPSS test results also demonstrate that the null hypothesis of no unit root is rejected for the levels of the cash and futures prices, and is not rejected for the first difference of the cash and futures and for the error of the regression of the cash price on futures prices, respectively. The residuals from the

regressions of the levels of cash on futures are stationary for both the five and two-month horizons so cocoa cash and futures prices appear to be co-integrated by the Engle and Granger criterion for cointegration.

We also present results of Johansen (1988)'s co-integration test which is evaluated respectively by the trace and lambda-max statistics (See Table 2.1 on the next page).

Table 2.1 Results of Johansen Co-integration and Alternate Tests of Futures Market Efficiency and Unbiasedness: 2-Month Horizon

# of cointegrating vectors	Statistic	Value	Statistic	Value	Decision
0	104.694	19.96	97.63	15.67	REJECT
1	7.0685	9.42	7.06	9.24	ACCEPT
2) LR Test of (0, 1) restriction on the					
Cointegration relationship					
Variable Name	Coefficient	Standard Error	p>z		
Cash	1.01	0.004	0		
Futures	1				
		Constraints	1	[_ce1]fp =	1
			2	_ce1]constant	0
LR test of identifying restrictions	Chi-sq(1)	1.9	p>Chi-sq =	0.089	
3) Davidson and MacKinon non-nested test to discriminate between ECM (and ARCH-M- ECM) with and without efficiency and unbiasedness restrictions imposed					
Model			Inference		
ECM		H <sub>0</sub> : (4) is preferred			
	H <sub>0</sub> : (5) is preferred to (4)	to (5)			
	J-statistic = 0.61	J-statistic = 4.02	Model (5)	is chosen	
	p-value = 0.52	p-value = 0.02	Restrictions	are	valid
ARCH-M-ECM		H <sub>0</sub> : (4) is preferred			
	H <sub>0</sub> : (5) is preferred to (4)	to (5)	Model (5)	is chosen	
	J-statistic = 0.75	J-statistic = 4.22	Restrictions	are	valid
	p-value=0.63	p-value =0.01			

The lambda-max statistic is derived from a test of the null hypothesis that the cointegration rank is equal to  $r$  against the alternative that the rank is equal to  $r+1$ . In contrast, the trace test is derived from a test of the null hypothesis that the cointegration rank is equal to  $r$  against the alternative that the cointegration rank is  $k$  where  $r$  and  $k$  are positive integers.

From Table 2.1, the trace statistics corresponding to the null of zero and one cointegrating vectors for the two-month maturity are respectively 104.69 and 7.06 and the corresponding critical values are respectively 19.96 and 9.42. In comparison, the lambda-max statistics for zero and one cointegrating vectors for the two-month maturity are respectively 97.63 and 7.06 and the corresponding critical values are respectively 15.67 and 9.2. Clearly, both the trace and lambda-max (maximum Eigen-value) statistics of Johansen's co-integration test reject the null of zero cointegrating vectors, but confirm the presence of one co-integrating vector for the two-month horizon. Similar results are obtained for the five-month horizon. Given the hypothesis of zero and one cointegration vectors for the five-month horizon, the trace statistics are respectively 21.2 and 7.1 while the critical values are respectively 19.9 and 9.4, so the presence of one cointegration vector is confirmed while the absence of a cointegration vector is rejected.

Table 2.1 also contains the results of the two tests for long-run market efficiency, unbiasedness and a zero long-run constant risk premium for the two-month horizon. The first test involves imposing (0, 1) market efficiency, unbiasedness and zero long-run constant risk premium restrictions by means of likelihood ratio (LR) restrictions on the Johansen cointegrating vector in the ECM. Note that from our analysis so far, the relevant ECM model has a simple form where the dependent variable is the first difference of the cash price and the independent variables are (i) the first difference of the futures (ii) the lag of the first difference of the cash price and (iii) the error from the OLS regression of the cash on futures. Regression results of the ECM are

presented in column 1, Table 2.3. It is clear that the absolute value of the coefficient of the error correction term  $\rho$  is significantly different from zero, as it should be in any well-defined ECM.

Using the first test of long-run market efficiency, we fail to reject the null hypothesis of long-run market efficiency, unbiasedness and zero long-run constant risk premium (p-value 0.089) for the two-month forecast horizons. Similar results are obtained for the five-month horizon. Given the (0, 1) restrictions in the ECM, we obtain a p-value of 0.091 for the five-month horizon so the futures market is long-run unbiased and efficient for both five and two-month horizons.

Although we focus here on the ECM results, the results of the tests for ARCH effects (Table 2.2) identified a significant term (ARCH 3) in the error of the ECM so in theory, an ARCH-M-3-ECM is the more appropriate model. However because we discovered that the non-negativity constraints for the variance terms in the ARCH-3-M-ECM are violated (Table 2.3) we will focus on the ECM results and report the ARCH-M-3-ECM strictly for the purposes of comparison.

Table 2.2 LM Test Results for ARCH Conditional Volatility: Two-Month Horizon

1 lag	0.93	$u_{t-1}^2 = 0$
2 lags	0.96	$u_{t-1}^2 = 0$
		$u_{t-2}^2 = 0$
3 lags	0.008	$u_{t-1}^2 = 0$
		$u_{t-2}^2 = 0$
		$u_{t-3}^2 = 0$

Notes: The results identify a significant ARCH-3 term. Lags refer to the number of lagged squared residuals used in the LM ARCH test. p-values of the  $\chi^2$  distribution with appropriate degrees of freedom

Table 2.3 Results of the ECM and ARCH-ECM Estimation: Two-Month Horizon

	ECM	ARCH-3-M- ECM
m	20.7 (0.33)	37.75 (1.3)
$\psi_1$	0.63 (3.85)	0.7 (4.9)
$\Omega_1$	-0.16 (-0.41)	-0.41 (-2.23)
$\rho$	-0.8 (-4.10)	-0.89 (-5.25)
$\pi_0$	37.75 (1.3)	15267 (4.05)
$\Theta$		-0.007 (-0.53)
$\pi_{33}$		-0.52 (-2.44)
$R^2$		0.75

$$\text{i. ECM: } \Delta S_t = m - \rho \mu_{t-1} + \psi_1 \Delta F_{t-1} + \Omega_1 \Delta S_{t-1} + \theta \sigma_t + \sum_{j=2}^j \psi_j \Delta F_{t-j} + \mu_t .$$

$$\text{ii. ARCH-3-M-ECM: } \Delta S_t = m - \rho \mu_{t-1} + \psi_1 \Delta F_{t-1} + \Omega_1 \Delta S_{t-1} + \theta \sigma_t + \sum_{j=2}^j \psi_j \Delta F_{t-j} + \mu_t$$

$$\text{where } \sigma_t^2 = \pi_0 + \sum_{q=1}^Q \pi_{qq} \mu_{t-q}^2 \text{ and } \pi_0, \pi_{qq} > 0, \sum \pi_{qq} < 1.$$

ARCH-3-M-ECM diagnostics: a. Ljung-Box Portmanteau (Q) test for white noise of the errors. The null hypothesis is white noise. Q-Statistic = 29.1969, p-value = 0.8979; the error is white noise. b. Breusch-Pagan / Cook-Weisberg test for heteroskedasticity. The null hypothesis is a constant variance. p-value = 0.3772; the variance is constant. Breusch-Geoffrey LM test of autocorrelation of the errors. The null hypothesis is no serial correlation. p-value = 0.217. c. Ramsey test of omitted variables, which has a null hypothesis of no omitted variables. p-value = 0.409 so no attenuation bias. Dummy variable are insignificant so coefficients and statistics are omitted.



Further evidence that the futures market is long-run unbiased and efficient is provided in Table 2.1. Table 2.1 displays results of the second test of market efficiency using the two-month forecast horizon: Davidson and MacKinnon (1981)'s non-nested J-type test to discriminate between an ECM with (equation 5) and without (equation 4) long-run unbiasedness and efficiency conditions imposed. Results in Table 2.1 (sub-division 3) using the two-month horizon indicate that the cocoa futures market is long-run unbiased and efficient assuming a zero constant risk premium since model (5) is selected over model (4). This can be seen from careful analysis of the information provided in the third (3) horizontal sub-divisions of Table 2.1. The third sub-division of Table 2.1 shows that with a p-value of 0.089 we fail to reject the restrictions of zero long-run constant risk premium and market unbiasedness in the ECM context.

Failure to reject the null hypothesis of long-run market efficiency and unbiasedness does not necessarily imply short-run efficiency and unbiasedness. To test short-run market efficiency and for a risk premium we exclusively use the two-month horizon because the five-month maturity contract yields insufficient data.

To test for a time-varying risk premium, we first tested for evidence of non-constancy in the variance of the ECM using LM ARCH tests. A non-constant variance points to bias in the short run which may be caused by the presence of a time-varying risk premium. Results in Table 2.2 indicate the presence of a significant ARCH-3 term which means that the conditional variance is non-constant. However, again, since the non-negativity constraint is violated a time-varying risk premium cannot be confirmed. We thus focus on the results of tests for short-run market efficiency and unbiasedness and for a time-varying risk premium using the ECM. Results of tests performed using the ARCH-3-M-ECM are reported strictly for the purposes of comparison. Note that similar to the procedure in McKenzie and Holt (2002), the conditions for long-run market

conditions for unbiasedness, efficiency and for a zero risk premium were imposed in the ECM prior to testing for efficiency and for a risk premium but results are largely identical to results from the unrestricted model.

From Column 2, Table 2.3, the non-constant variance identified in Table 2.2 does not contribute to a time-varying risk premium because  $\theta$ , the coefficient of the conditional variance term, is insignificant. This implies although we found an ARCH effect (albeit with an unexpected sign), it was not significant in the mean equation. The finding of a zero risk premium is not surprising because ARCH-type effects are usually found in data with extremely high frequency. Lower frequency data smooth the series rendering it difficult to capture the ARCH-type effect that measure the risk premium (Frank and Garcia, 2009). Interestingly, Subahuro and Larue (1997) and Frank and Garcia (2009) also find no risk premiums in futures markets using the two-month horizon for different commodities although short-run biases were sometimes present. We test for and reject short-run market efficiency and unbiasedness using the ECM and tests derived by McKenzie and Holt (2002); the results are presented in Table 2.4.

Table 2.4 Tests of Short-Run Market Efficiency, Unbiasedness and Risk Premium: Two-Month Horizon

	$\rho = 1$	$\alpha_1 = 1$	$\theta = 0$
	$\rho\alpha_1 = 1$	$\psi_1 = 1$	
	$\psi_1 = 1$	$\psi_i = 0$ for $j \text{ not} = 1$	
	$\Omega_i = \Omega_j = 0; i, j \text{ not} = 1$	$\Omega_i = 0$	
		$\theta = 0$	
	$m = 0$	$m = 0$	
P-Value for chi-square	0.0	0.00015	0.125
Conclusion	Reject $H_0$ :	Reject $H_0$ :	Do not reject the null

- (1) The short-run conditions for short-run market inefficiency and unbiasedness given long-run market efficiency and unbiasedness can also be found in McKenzie and Holt (2002).
- (2) Column 1 contains the results of tests of short-run market efficiency, column 2 contains results of the test of short-run unbiasedness, and column 3 contains the results of the test for the identification of the Risk Premium.

Although the finding of co-integration of cash and futures price suggests long-run unbiased futures forecasts of subsequent prices, Table 2.4 provides evidence of short-run bias and market inefficiency or informational inefficiency in the ECM, since the null hypotheses of short-run market efficiency and unbiasedness are rejected. The futures market is biased in the short run (See Column 1, Table 2.4), but it is most likely that the bias emerges from an informational inefficiency because there is no time-varying risk premium ( $\theta$  is insignificant). The insignificance of  $\theta$  provides evidence of an insignificant time-varying risk premium. However, evidence of a zero constant risk premium is also immediately available since  $\alpha$ , the constant is zero in the long run relationship (Table 2.1) so there is no constant risk premium in the long run. Since the

constant in the short-run relationship also is zero there is no constant risk premium in either the long or short runs.

Confirmation of short-run futures market inefficiency is provided by the test of short-run market inefficiency. From the results in column 1, Table 2.4, the null hypothesis that the futures market is efficient in the short-run is rejected, so the short-run bias is due to (informational) inefficiency, not a time-varying or constant risk premium.

## 2.6 OUT-OF-SAMPLE ANALYSIS

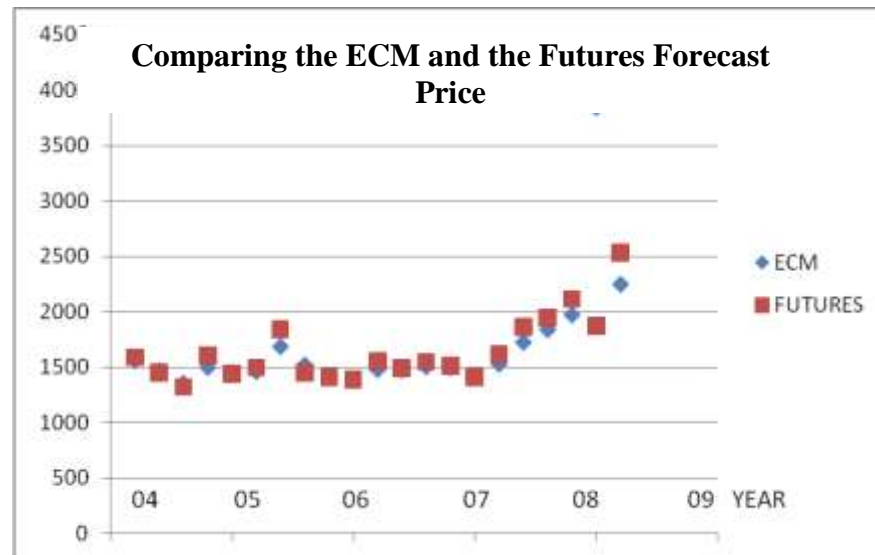
In light of the results of short-run market inefficiency, it is important to assess out-of-sample forecast accuracy of futures prices relative to the ECM, and to estimate the magnitude of the inefficiency. This is vital because all the efficiency tests carried out so far used in-sample data and were predicated on the necessary condition for market efficiency (Fama, 1970) although the sufficient condition for efficiency is positive, economically relevant risk-adjusted profit. Before we move to the sufficiency criterion, however, it is instructive to note that stronger formal tests of efficiency using the necessary condition and out of sample data are available. Out of sample analysis is typically more robust relative to in-sample results. We discuss two of such tests below as a check for our in-sample results.

### *The Test of Forecast Encompassing and the MDM Test*

To formally assess out-of-sample forecast accuracy, two procedures were used: A regression-based test of forecast encompassing used by Sanders and Manfredo (2005), and the Modified Diebold and Mariano's or the MDM test. The futures forecasts were used as the preferred forecasts in both tests. A plot of the 21 forecasts generated using both futures and the

ECM from 1980.1 to 2008.1 (since there are 5 contracts in a month) are presented in Figure 2.3. The forecasts are visually similar albeit with some divergences.

Figure 2.3 A Plot of the ECM Forecast and Futures Forecast of Prices (\$/ton)



Both the encompassing test and the MDM tests assess pricing efficiency (Sanders and Manfredo, 2005). Pricing efficiency as defined here is equivalent to informational efficiency. There are two dimensions to assessing pricing efficiency: (i) are there other forecasts that are more accurate than the preferred forecast or the futures (necessary condition)? and (ii) if so, do these other forecasts allow us to generate risk adjusted profits (the sufficient condition).

The encompassing and the MDM tests are used in the first step, to assess the necessary condition but not the sufficient efficiency condition and imply that the forecast error of the preferred forecast must be orthogonal to all variables in the information set, especially the forecast error of the competing forecasts (Kaminsky and Kumar, 1990; MH, 2002; Sanders and Manfredo, 2005).

### *Mechanics of the Test of Forecast Encompassing and the Link to the MDM*

As MH (2002) explain, whether the futures forecast error is orthogonal to the variables in the information set can be tested by the simple regression equation in (i)

$$(i) \quad S_t - f_{t-n} = \alpha + \beta X_{t-n} + \varepsilon_t$$

where  $S_t$  is the cash price (or alternatively the expiration day futures price),  $f_{t-n}$  is the futures forecast price,  $n$  periods prior to expiration and  $X_{t-n}$  is a vector of information- containing variables. In particular, suppose we choose the futures forecast as the preferred forecast. Then if we assume that  $X_{t-n}$  is an alternative forecast  $f_{t-n}^a$  to the preferred forecast (the futures), the null hypothesis of market efficiency will posit that  $\beta = 0$  in regression (ii) below:

$$(ii) \quad f_t - f_{t-n} = \alpha + \beta (f_t - f_{t-n}^a) + \varepsilon_t .$$

By performing a simple mathematical exercise involving adding and subtracting the alternative forecast  $f_{t-n}^a$  from (ii) we arrive at equation (iii)

$$(iii) \quad e_{1t} = \alpha + \lambda (e_{1t} - e_{2t}) + \varepsilon_t$$

where  $e_{1t}$  is the future's forecast error or the difference between the futures forecast price and the futures price at expiration and  $e_{2t}$  is the alternate forecast error or the difference between the alternative forecast (the ECM) and the futures price at expiration. Coincidentally, equation (iii) is precisely is precisely Harvey, Leybourne, and Newbold's (1998) test for forecast encompassing and is theoretically consistent.

A test of the null hypothesis,  $\lambda = 0$ , in equation (iii) is a test of the null that that the covariance between  $e_{1t}$  and  $(e_{1t} - e_{2t}) = 0$ . A failure to reject the null hypothesis implies that a composite forecast cannot be constructed from the two series that would result in a smaller expected squared error than using the preferred forecast (the futures) by itself. In this case, the

preferred forecast is said to encompass the alternative forecast. The preferred forecast is “conditionally efficient” (Harvey, Leybourne and Newbold, 1998).

The MDM and encompassing tests have the same null hypothesis: that the forecast error of the preferred forecast must be orthogonal to the forecast error of the competing forecast. A non rejection of the null hypothesis implies that the preferred (futures) encompass the competing forecast and establishes efficiency for both tests. The difference between the two tests is that MDM test is more powerful than the regression based encompassing test in small samples (Sanders and Manfredo, 2005).

Note that the futures forecast or the preferred forecast recorded a larger loss functions (MSE) compared to the ECM forecast which was the competing forecast so the futures is less likely to provide more accurate forecasts relative to the ECM. As Sanders and Manfredo (2005) explain, however, in determining pricing efficiency, results of tests of encompassing are preferred to comparison of forecasts using the lower MSE criterion. In performing the encompassing tests, the residuals of all regressions were tested to ensure that they were white noise. If the errors in the encompassing regressions were not white noise then the encompassing test results would have been invalid.

Results from both the regression-based encompassing test and the MDM test both suggest that futures forecasts is inefficient in the short run using the necessary condition for futures market efficiency as a criterion. As previously stated, Twenty-one out-of-sample forecasts (2004.1-2008.1) were generated from the ECM and used to perform the tests. Using the ECM forecast, the p-values of the regression-based encompassing test and MDM tests were respectively 0.001 and 0.003, indicating a rejection of the null hypothesis in both tests.

Different loss functions for example, the Mean Absolute Error (MAE) and the Mean Absolute Percent Error (MAPE) were employed in the MDM test, but the primary conclusion that futures did not encompass alternative forecasts was consistent across type of loss function used. Since futures fails to encompass the ECM forecast, the futures market is informationally inefficient in the short run by the encompassing criterion.

To assess the magnitude of the inefficiency in the futures market, we calculate the return and standard deviation from a *buy* (sell) and offset strategy when the alternative forecast price is *above* (below) the futures' forecast. The average profit and standard deviation from the simple buy (sell) and offset strategy for the ECM forecast are \$37.05/ton and \$207.4/ton, respectively. The mean percent return was 2.5 and its standard deviation was 0.12. In calculating returns, we use 10% of the futures contract price as the cost of holding the futures position or the initial margin (Lukac, Brorson and Irwin, 1988). We subtract this from the futures at expiration to obtain the return. The corresponding annualized positive returns of 4.2 suggest market inefficiency.

On the surface the annualized positive returns of 4.2% seems very large but considered in the light that only 10% of the initial futures position is counted as cost the return is much less impressive. In fact, while the average percentage return is positive, it is doubtful any investor will invest in cocoa futures unless it is economically relevant. To examine this more carefully, we calculate the most commonly used measure of risk-adjusted return, the Sharpe ratio (see Sharpe, 1966; 1975 and 1994), using the interest paid for a three-month U.S Treasury bill. Traditionally, the risk-free rate of return used in computing the Sharpe ratio is the shortest dated government T-bill (i.e. U.S. T-Bill). Note that the Federal Reserve does not report the yield on a two-month treasury bill, which is our relevant forecast horizon. The Treasury bill held for the shortest time is the three-month note. We therefore calculated the Sharpe ratio using the interest paid for a three-



month Treasury bill (CNN Money, October 2008). The Sharpe ratio is defined as the ratio of the difference between expected and market returns to the standard deviation of the expected return (Sharpe, 1966; 1975 and 1994). We computed the Sharpe ratio in two steps: In step 1, we subtract the market return from the average of the returns computed from the buy and hold strategy. In Step 2 we divide the value obtained in step 1 by the standard deviation of expected returns (from the buy and hold strategy) and obtained a Sharpe ratio value of 0.27. This value of the Sharpe ratio is quite low and likely to be very unattractive to most investors because the risk associated per unit of return is disproportionately large (Sharpe, 1994). A Sharpe ratio less (more) than one implies that for every unit of return above the market rate an investor must accept risk considerably larger (smaller) than market risk.

Further, once the returns are adjusted for transaction and transportation costs they might yield a zero or negative value, making a strategy to invest in cocoa futures extremely unlikely. The transactions cost comprises of both a fixed cost which declines with number of contracts and a cost per contract (brokerage fee), so it can be substantial. Since the risk premium is zero, a value of the transactions cost equal to the risk adjusted positive return (the Sharpe ratio) will immediately drive profits to zero invalidating the need to invest in futures contracts.

To keep the argument balanced however, recall that the Sharpe ratio penalizes all variability in the revenue returns as risk and not just losses of revenue as the measure of risk (standard deviation) is not a downside risk measure but rather a two-sided risk measure. The Sharpe ratio may therefore over-state the effect of risk in the return versus comparison used to calculate the Sharpe ratio. This is true because it is plausible that some investors may really prefer upside return movements because this logically translates into profit and not risk (Mattos, Garcia and Pennings, 2008).

Although it appears there are systematic patterns in cocoa prices, and that alternative forecasts do provide information to the futures market, it is difficult to take advantage of them in an *ex ante* context so the magnitude of the short-run inefficiency is small and should not deter effective hedging. We have reasonable confidence in the results as we did not notice any extreme outliers in the forecasts. While the necessary condition for market inefficiency is satisfied because returns from the buy and hold strategy are positive, the sufficient condition for market inefficiency is not achieved as the positive returns are economically irrelevant. These results are consistent with the notion that high volatility in agricultural markets makes forecasting problematic and identification of profitable strategies difficult.

We note here that the apparent inconsistency between the encompassing test results that specify inefficiency and the profit analysis that specify efficiency is no inconsistency at all. The clarification needed here is that the encompassing test only satisfies the necessary condition for efficiency so the finding of positive profit is actually consistent with market inefficiency. Sanders and Manfredo (2005) also reported inconsistency between encompassing and profit analysis results, so it is not a surprising occurrence. However similar to what is reported here they emphasize that the encompassing test is an insufficient test of efficiency. Association of gross profit with the encompassing test result of inefficiency is valuable, because it provides some statistical support for the results of the statistical test of short-run inefficiency and unbiasedness conducted within the framework of the time series model (Sanders and Manfredo, 2005).

The finding of economically irrelevant profit here, however, is in line with the sufficient condition for efficiency.

## 2.7 CONCLUSIONS

The futures market is one way Sub-Saharan Africa's cocoa exporters can hedge export price risk. However, efficient hedging is compromised if futures markets are inefficient, and costly if speculators demand a significant constant or time-varying risk premium to bear spot price risk. Using two and five-month hedge horizons we find that the cash and futures prices are co-integrated and that the futures market is unbiased and efficient in the long run. The result of co-integration is consistent with the results of Beck (1994) and Subahuro and Larue (1997) but not with Manayi and Struthers (1997). Long-run market efficiency and unbiasedness implies that it is feasible for SSA exporters to hedge price risk with futures markets because futures prices provide accurate forecasts of the subsequent period cash price.

In contrast, the futures market is found to be short-run biased using a two-month horizon by the necessary condition for futures market efficiency. Short-run bias may be caused by informational inefficiency or a risk premium. Decomposing short-futures bias into bias caused by risk premiums or informational inefficiency has proven challenging in the literature (Frank and Garcia, 2009). We employed McKenzie and Holt's procedure and NYBOT futures to identify short-run bias, inefficiency and the absence of both a constant and a time-varying risk premium in the cocoa futures market. The absence of a risk premium is consistent with Frank and Garcia (2009). Our initial finding of limited short-run futures market inefficiency by the necessary criterion is in line with the findings of Manayi and Struthers (1997). We find that short-run futures market bias is due to an information bias and not to a time-varying risk premium. Further, although it may be possible to exploit the informational inefficiency to make money in the short-run, substantial inherent market risk makes investing in cocoa futures unattractive. Since short-run informational inefficiency only yields economically irrelevant profit when considered on a

risk adjusted basis the futures market is actually efficient by the sufficient condition for efficiency.

The primary conclusion that the futures market is long-run unbiased and efficient should be welcome news to SSA governments desiring to use the futures markets for hedging export price risk, as futures market efficiency is a necessary condition to hedge export price risk with futures markets. The absence of a time-varying or constant risk premium is one less unobserved cost that hedgers need to consider in deciding to hedge export price risk. A zero risk premium together with both short and long-run market efficiency and unbiasedness suggests that export price risk hedging with cocoa futures markets is a feasible option for Sub-Saharan Africa cocoa exporters.

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## ESSAY 3: HEDGING JOINT PRICE AND PRODUCTION RISK: THE CASE OF GHANA COCOA

### 3.0 SUMMARY

This paper assesses the usefulness of risk hedging on futures markets for a cocoa exporter subject to concurrent price and output (revenue) risks. The analysis is conducted for Ghana, the world's second largest exporter of cocoa beans. Using cocoa export revenue data, the cocoa exporter's utility maximization problem (UMP) is solved using a Constant Relative Risk Aversion (CRRA) utility function which displays risk vulnerability, a natural restriction on preferences. Simulation results from the utility maximization problem indicate that as a result of production risk, optimal revenue hedge ratios are much smaller than optimal price risk hedge ratios for reasonable values of the risk parameter. When transaction costs are incorporated, optimal revenue hedge ratios decline further although they remain positive verifying previous findings. The findings generated here in the context of a commodity framework indicate limited hedging with futures contracts by Ghana's Cocoa Marketing Board may be warranted.

### 3.1 INTRODUCTION

Governments of cocoa exporting Sub-Saharan African (SSA) countries typically depend heavily on cocoa export revenue to finance development projects (Borenstein, Jeane and Sandri, 2009; Razzaque, Osafo-Kwaako, and Grynberg, 2007). Export revenue variability emanating from either price or production instability can lead to undesirable consequences for exporters largely dependent on a narrow range of commodities (Newbery and Stiglitz, 1981; Razzaque,

Osafo-Kwaako, and Grynberg, 2007). For instance, export revenue risk can increase the likelihood of default on sovereign debt and also lead to macroeconomic instability in export revenue-dependent countries (Malone, 2005).

This paper focuses on the export revenue risk problem facing Ghana, the second largest cocoa exporter in the world. Ghana is chosen for analysis because it is somewhat typical of the cocoa exporting SSA countries and relies heavily on cocoa exports; cocoa provides nearly thirty percent of Ghana's export revenue (Pinnamang-Tutu and Armah, 2011).

Export revenue risk has assumed great importance recently because non-market strategies including buffer stocks, buffer funds and commodity agreements failed to effectively reduce revenue risk (Borenstein, Jeane, and Sandri, 2009; Larson, Anderson, and Verangis, 2004). Further, because of the recent efforts by the World Trade Organization (WTO) to liberalize markets and foster competition in world markets, risk management methods such as international cocoa agreements and buffer stocks are not likely to be encouraged in the future (Lence, 2009; Borenstein, Jeane, and Sandri, 2009). As an alternative, market-based risk management strategies including hedging may be used to manage export revenue risk.

Like Ghana, the majority of SSA's major cocoa exporters administer exports through legislatively defined cocoa marketing boards although the largest cocoa producer (Cote d'Ivoire) has partly liberalized the export of cocoa. Given the structure of cocoa marketing in SSA, this research examines whether a centralized marketing board like Ghana's COCOBOD can use futures markets to mitigate revenue risk. In particular, the paper seeks to answer to the following questions: (i) Should Ghana use the futures markets to mitigate price and output (revenue) risks? (ii) Will futures hedging of revenue risk increase exporter's welfare relative to the unhedged position? (iii) How large should optimal hedge ratios be after accounting for transaction costs

which have been shown in prior research to affect their attractiveness? Answers to these questions can provide information on the effectiveness of futures markets in hedging revenue risk.

Ghana differs from other African cocoa producers (Cote d'Ivoire (CIV), Togo, Cameroon, Nigeria and Uganda) because it produces the world's highest quality cocoa and thus enjoys a significant quality premium. At the moment Ghana does not hedge but rather sells all its cocoa mainly to European buyers using forward contracts which recognize the differential quality of Ghana-origin cocoa (the Golden Pod).

The COCOBOD reports negligible cocoa trading activity between Ghana and USA merchants. The reason for the low Ghana-USA cocoa trade is that USA chocolate manufacturers (e.g. Hershey) do not specialize in making chocolate with a large proportion of high quality beans and are thus unwilling to pay the premium for Ghana cocoa. Trade in cocoa between Ghana and USA also is less attractive because of the relatively high shipping costs which can reach three times the rate that exists between Ghana and Europe (e.g., Ghana-UK \$250/ton compared to Ghana-US \$750/ton, COCOBOD). Despite reports of limited cocoa trading between Ghana and the USA, there is no *a priori* reason why Ghana cannot hedge on the New York Board of Trade (NYBOT) futures market if its utility as a producer country is enhanced by hedging on the NYBOT.

In a well-known paper, Rolfo (1980) analyzed the Utility Maximization Problem (UMP) facing a cocoa exporting country exposed to simultaneous price and production (revenue) risk, both of which plague cocoa producing countries. Rolfo (1980) focused on SSA's major cocoa exporters—Ghana, Cote d'Ivoire (CIV), and Nigeria—which combined account for nearly seventy percent of world production and depend to varying degrees on cocoa export revenues to fund development (Gibson, 2007).

Rolfo's problem formulation described a sovereign cocoa exporter exposed to concurrent price and production risk or revenue risk taking a pre-harvest (September) position in the futures market to establish a price at harvest (March). In the absence of production risk, a traditional recommendation of protecting a long position in a physical market involves taking a short position of equal size in the futures market (Hieronymus, 1971; Rolfo, 1980). Given production risk, Rolfo (1980) finds limited or no use of the futures markets is superior to a full hedge.

While Rolfo's analysis is highly informative, his findings may be limited in several dimensions. In particular in his analysis of the UMP facing the Ghana COCOBOD, he does not address the existence of the Ghana-origin cocoa quality premium nor does he identify why the COCOBOD should hedge given that it was already selling cocoa by forward contracts. Further, since his data covered the period 1956 to 1976, the results reflect price and production dynamics which may no longer be relevant for current hedging decisions. The New York Board of Trade (NYBOT) futures and subsequent spot (cash) prices measured in nominal \$/ton, and variance of futures prices for cocoa from 1960 to 2008 (shown in Figures 3.1 and 3.2 on the next page) provide clear evidence of a structural break in these variables around 1978. The earlier period was characterized by lower and less variable prices, and by a closer relationship between futures and spot prices.

Figure 3.1 Cash and Futures Cocoa Prices, 1960-2008

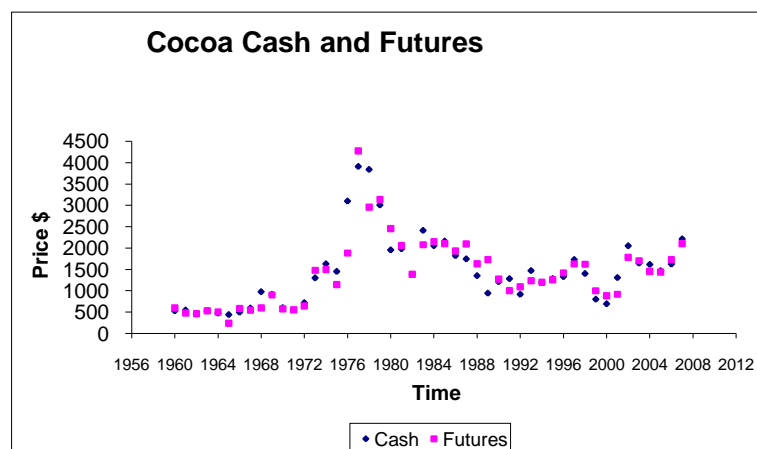
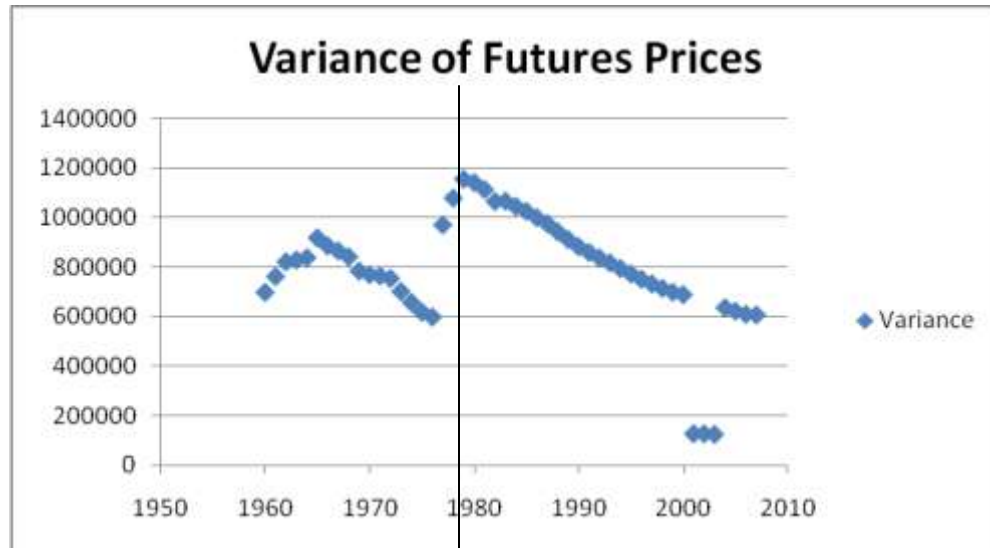


Figure 3.2 Futures Price Variances, 1960-2008



Statistical evidence of a structural break in the variance of futures prices is presented in Table 3.1 which displays results of the Miller Jackknife test, a non-parametric test of structural change in the variance that does not assume equal medians.

Table 3.1 Structural Break Test for the Variance of Cocoa Futures Price

	Structural				MI	
	Break	m	n	Q-Stat	P-value	
Standard Deviation of the Futures Price	July 1978	18	30	-5.0	<0.001	

Ho: The Ratio of the variances from the two periods is unity

Ha: Ratio of the variances from the two periods is not unity

m = number of observations before the break

n = number of observations after the break

MI: Miller jackknife test for differences in variance between two periods. For large m and n, Q converges to a standard normal distribution. High Q-Stat is strong evidence of a structural break.

From Table 3.1, the null hypothesis that the ratio of the variances of futures price before and after 1978 is unity is rejected at 5 % significance level. Since optimal hedge ratios are influenced either by changes in the correlation between cash and futures prices or by changes in the variance of the futures price (over time), the structural change in 1978 indicates a need to reassess the cocoa exporter's hedging decisions. More importantly, Rolfo's analysis ignores transaction costs. Mattos, Garcia and Nelson (2008) demonstrate that when transaction costs are considered when solving the utility maximization problem of an agent, optimal hedge ratios may change considerably.

Here using futures contracts on the NYBOT, the most liquid cocoa futures market in terms of volume of trade, we re-investigate the revenue risk problem facing Ghana, incorporating transaction costs and more recent data. Following Rolfo (1980), we first compute optimal hedge ratios using quadratic utility with zero transactions costs for different values of the Coefficient of Absolute Risk Aversion (CARA). Transaction costs are then incorporated into the cocoa exporter's utility maximization problem and the optimal hedge ratios are recalculated. We then repeat the analysis with a more realistic Constant Relative Risk Aversion (CRRA) utility function (Nelson and Escalante, 2004).

The Nelson and Escalante (2004) utility framework allows for the more reasonable Decreasing Absolute Risk Aversion (DARA) and Decreasing Absolute Risk Prudence (DAP) assumptions. The Nelson and Escalante (2004) utility function also displays risk vulnerability which is the most natural restriction on preferences (Gollier and Pratt, 1996; Mattos, Garcia and Nelson, 2008). A search program in Visual Basic was developed to compute optimal hedge ratios by solving the UMP of the cocoa exporter with Nelson and Escalante (2004) type preferences exposed to revenue risk and transaction costs. Optimal hedge ratios are positive even when

transactions costs and production risks are incorporated into the UMP of the cocoa producer but they are small in magnitude. Thus, the essay finds that hedging appears to offer a small utility-improving opportunity, suggesting that it may be of value for the cocoa Board to assess the usefulness of futures hedging within the structure of its operational decisions and the details of the contracts offered by its buyers.

### 3.2 LITERATURE REVIEW

Rolfo maximized logarithmic utility and quadratic utility functions to develop optimal hedge ratios from the utility maximization problem. The log utility function displays Constant Relative Risk Aversion (CRRA), a realistic preference representation, but does not allow the risk parameter to vary as it is fixed at unity. The log utility assumption is thus restrictive and unlikely to be very useful because it does not allow analysis of how the hedge ratios change as the risk parameter changes.

In comparison, the quadratic utility function implies increasing relative risk aversion (which means that risky assets are inferior goods) and satiation (which means that the utility starts decreasing after a satiation point), both of which are inconsistent with observed behavior (Mattos, Nelson and Garcia, 2008; Nelson and Escalante, 2004). However, given quadratic utility, preferences can be represented by the mean and variance of the underlying wealth distribution, greatly simplifying the utility maximization problem (Rolfo, 1980).

The simplicity of the computation of the mean-variance hedge (MVH) derived by assuming quadratic utility explains its popularity in the literature despite inconsistency with the actual behavior of economic agents (Outtara, Schroeder and Sorenson, 1990; Lence, 1996). Although more recent literature no longer assumes preferences with quadratic utility due to its

unrealistic properties, the mean-variance model (that is typically implied by quadratic utility) is still used assuming CARA utility and normally distributed returns.

Here, we also employ a CRRA utility function first defined by Nelson and Escalante (2004) which is consistent with observed behavior because it displays Constant Relative Risk Aversion (CRRA) and Decreasing Absolute Risk Aversion (DARA), Decreasing Absolute Risk Prudence (DAP) as well as risk vulnerability. According to Gollier and Pratt (1996) “preferences exhibit risk vulnerability if the presence of an exogenous background risk with a non-positive mean, namely an unfair risk, raises the aversion to any other independent risk.” In comparison, risk prudence refers to the propensity of the individual to save more when faced with riskier outcomes and is not identical to risk aversion which means the individual dislikes risk. In particular, the utility function of a risk-averse agent has a negative second derivative while the utility function of the risk prudent agent has a positive third derivative. DAP therefore means the agent is less prudent the wealthier he gets. According to Eeckhoudt and Rey (2011). “Vulnerability adds to prudence what DARA adds to risk aversion.”

CRRA, DARA, DAP and risk vulnerability are desirable characteristics of utility functions (Gollier and Pratt, 1996; Nelson and Escalante, 2004; Mattos, Garcia, and Nelson, 2008). Since Gollier and Pratt (1996) demonstrate convincingly that risk vulnerability is the most natural restriction of utility functions, the Nelson and Escalante (2004) CRRA utility function, which is risk vulnerable, is best suited for modeling risk preferences of agents and is employed in this research.

Apart from unrealistic preferences, changes in the assumptions used to develop optimal hedge ratios can influence their magnitude and usefulness (Benninga, Eldor, and Zilcha, 1984). In particular, when the assumptions underlying the derivation of the mean-variance hedges



(MVH) using CARA utility change, MV hedges change dramatically (Lence, 1996). Although both Rolfo (1980) and McKinnon (1967) relax the zero production risk assumption neither takes into account how transaction costs, such as brokerage fees, can affect the optimal hedge ratios. We relax both assumptions and investigate how production risks and transaction costs simultaneously affect the optimal hedge assuming the cocoa exporter has realistic preferences.

Following Rolfo (1980), Sy (1990) and Outtara, Schroeder and Sorenson (1990) also examined the costs and benefits of hedging commodity export revenue risk in a utility framework. Sy (1990) compared the relative costs and benefits from hedging the revenue risks of a basket of goods (cocoa, coffee and cotton) for La Cote d'Ivoire or the CIV.

Sy (1990) focused primarily on the change in utility from hedging price risk when production risk is introduced into the standard price risk hedging problem. He then compared the gains from minimizing risk using futures markets with gains in utility from mitigating risk using stabilization programs. In contrast to Rolfo (1980), Sy (1990) does not define a pre-harvest to harvest hedge horizon for his analysis. Instead, he defines an annual export price index as the ratio of annual total export revenue to the total export volume. He uses this annual price index (the cash) and annual average New York Stock Exchange futures prices from 1973 to 1984 to compute MVH ratios by Ordinary Least Squares. Consistent with Rolfo (1980)'s findings, Sy (1990) concludes the hedge ratios for mitigating cocoa price risk alone are positive and smaller than unity.

In contrast to Rolfo's conclusions, Sy (1990) finds that when production risk is introduced, the sign of hedge ratios are ex ante unclear. They can be positive or negative depending on the joint distribution of futures prices, cash prices and production. However the benefits from market risk management exceed the benefits from stabilization policies so CIV

would benefit greatly from hedging cocoa market risks. Similar to Rolfo, Sy (1990)'s findings may be dated and not necessarily relevant to the contemporary risk management problem that SSA cocoa exporters face. Further, Sy (1990) also fails to include and analyze effects of transaction costs on the optimal hedge ratios.

In terms of objectives, structure and findings, the paper by Alexander, Rauser and Musser (1986) comes closest to Rolfo's paper. Although they analyzed a grain producer in the developed world (USA) the authors use a similar simulation method. What Alexander, Rauser and Musser (1986) contribute is an analysis of the effect of different financial risks on hedging decisions. In particular they modeled the UMP facing the grain farmer as one of a choice between keeping capital locked up in a hedging activity and placing the capital in the bank to earn interest. Not surprisingly they conclude that the opportunity cost of not hedging negatively influence hedge ratios and that hedge ratios decline the lower the expected market return.

Outtara, Schroeder, and Sorenson's (1990) research is also relevant here because they use a similar method to Rolfo (1980) to analyze a similar problem. Outtara, Schroeder, and Sorenson (1990) investigated the possibility of reducing CIV coffee marketing board's export revenue risk by using futures markets. Following Rolfo (1980), they develop optimal hedge ratios by maximizing a quadratic utility function for a coffee exporter exposed to export revenue risk. Futures prices from 1973/74 to 1986/87 were collected to generate forecast errors using the coffee contract on the New York Sugar, Coffee and Cocoa Exchange (SCCE). Cash prices and output forecasts were obtained from the United States Department of Agriculture (USDA). The futures forecast price used was the May closing futures reported on the last day of October, while the futures price at expiration is the May futures reported on the first day of May. They concluded that CIV could reduce revenue risk by 29 percent if it hedged 125 percent of production over the

1973/74 to 1986/87 period. Since Outtara, Schroeder, and Sorenson (1990) suggest that CIV should hedge more than total output; CIV derives speculative profits from declining prices over the period. However, speculation is an undesirable strategy given their risk minimizing objective. Similar to Rolfo (1980) and Sy (1990), Outtara, Schroeder, and Sorenson (1990) use a CARA utility function. Further, like Rolfo (1980) and Sy (1990), Outtara, Schroeder, and Sorenson (1990) do not investigate the effect of transaction costs on the optimal hedge ratio.

Borenstein et al (2009) also investigate the UMP facing an agricultural producing country exposed to revenue risk. Although they focused only on price risk, they highlighted another utility-enhancing property of hedging not previously considered in detail in the literature (see Malone (2005) for an early discussion). Specifically, Borenstein et al (2009) used a dynamic optimization model to estimate the welfare gains from hedging against commodity price risk for commodity-exporting countries. They consider a small open economy that is exposed to shocks in the price of the commodity that it exports. They then compare welfare from two scenarios: a baseline no-hedging case to the hedging case where hedging is done using futures contracts. They find that hedging provides benefits by: (i) reducing income volatility and smoothing consumption, and (ii) reducing the propensity for the exporting country to hold foreign assets as precautionary saving. This paper focuses on the first dimension of benefits although the benefits from the precautionary motive are also likely to be substantial since the interest on country debt is reduced.

In another contribution, Lence (2009) solves the UMP facing an agricultural producer such as a cocoa exporter exposed to revenue risk. He investigates whether atomistic producers in developing countries should hedge revenue risk using a dynamic model that allows for price to influence expected production. He concludes that hedging reduces risk, increases production and

lowers price because of a downward sloping demand function. Hedgers "win" when their production is small but lose when their production is large. For large hedgers, he finds hedging is sub-optimal because it reduces their welfare. However, it is important to recognize that the structure of the UMP in Lence (2009) is somewhat different from the problem discussed in this paper. Here we investigate the market activities of Ghana's Cocoa Marketing Board (COCOBOD) which is responsible for exporting cocoa, not the production activities of atomistic producers as in Lence (2009). Producers in Ghana do not sell on the world market, but rather they sell to the marketing board at a "fixed price" which means that there is no added risk-reducing increase in production from the use of futures. Consequently, the reduction in producer welfare due to hedging that Lence (2009) identified will not likely be observed here.

We contribute to the literature by analyzing the cocoa exporter's revenue-risk problem as originally defined by Rolfo (1980) but using a more nuanced specification of risk preferences in the post structural break cocoa market. While we examine Rolfo's original formulation, we focus on a more realistic utility function (Nelson and Escalante, 2004) that exhibits decreasing absolute risk aversion (DARA), constant relative risk aversion (CRRA), risk vulnerability and decreasing absolute risk prudence (DAP). Like, Borenstein et al (2009), Rolfo (1980), Sy (1990) and Lence (2009), we determine if risk hedging is utility improving compared to the no hedging situation when transactions costs are zero. We then analyze the effect of transactions costs on the optimal hedge ratio and exporter utility.

Despite the extensive literature on minimizing production risk (See for example, Mckinon 1960; Rolfo, 1980; Newbery and Stiglitz, 1981; Alexander, Muser and Mason, 1986, Outtara, Shroeder, and Sorenson, 1990; Lapan and Moschini, 1994, Lence 1996; Agalith, 2006 and Lence, 2009), this line of research has been criticized by Just, Khantachavana and Just (2010). In

particular Just et al claim the existing literature on production risk (i) cannot discern production risk preferences, (ii) cannot discern the factors that relate to production risk preference and (iii) is replete with evidence that prior estimations of production risk were incorrect. Note that Just et al were concerned with literature on production risk that model producer preferences in formulating risk minimization strategies. Since we do not model producer preferences here the concerns raised by Just et al are essentially second-order problems from the COCOBOD's perspective.

### 3.3 PROBLEM FORMULATION, MODEL AND METHODS

Despite export and domestic market liberalization in the 1990's, a substantial amount of the cocoa exported from Sub-Saharan Africa (SSA) is still controlled by governmental agencies and not by private agents (Dand, 1999; COCOBOD, 2011). In Ghana, in spite of domestic market liberalization in 1994, the government-run Cocoa Marketing Board or COCOBOD remains a monopoly exporter of Ghana cocoa (Bulir, 2002). Pinnamang-Tutu and Armah (2011) and Appendix B contain further details of the institutional organization of cocoa marketing in Ghana. There are several private Licensed Buying Agents (LBAs) that can purchase the cocoa directly from the farmers but these LBAs must resell all the cocoa to COCOBOD at the Takoradi port for export (COCOBOD, 2011; Dand, 1999). Hence, COCOBOD is Ghana's sole decision maker on the marketing and exportation of Ghana cocoa.

Substantial production variation exists in cocoa harvested and exported due to unexpected rainfall patterns, diseases and pest attacks (Rolfo, 1980; COCOBOD, 2000). COCOBOD is therefore concerned about production risk and revenue risk. Further, COCOBOD is also concerned about the effects of price variability on export revenue risk because it directly faces

the world cocoa prices which exhibit considerable price variability reflecting inelastic demand and inelastic supply (Razzaque, Osafo-Kwaako, and Grynberg, 2007).

To model hedging behavior, we posit that COCOBOD takes a pre-harvest position in the futures market in order to guard against unexpected variation in cocoa export revenues emanating from price or output risk at harvest. The main Ghanaian cocoa harvest commences in October and ends in January. The hedge uses New York Board of Trade (NBYOT) futures contracts and is assumed to be placed on the first trading day of July (pre-harvest) and closed on the last trading day of December (harvest). This six-month hedge horizon was selected for analysis of the revenue risk minimization problem using futures markets because it is both convenient and representative of the marketing situation faced by COCOBOD. The NYBOT exchange has five contract months in a year: March, May, July, September and December making the July-December hedge horizon particularly amenable for analysis. At the decision date (pre-harvest,  $t = 0$ ), the COCOBOD can sell  $h$  commodity contracts on the exchange each of which reflects a specific production quantity in the futures market at price  $f$ . At harvest ( $t = 1$ ), COCOBOD can deliver the quantity of cocoa specified by the contracts to an identified delivery point which is unusual or can simply repurchase cocoa at the random futures price  $P_f$  on the exchange. Cash sales are made at the end of the hedging period, and COCOBOD will receive that price. Conceptually, losses in the cash market can be recouped in the futures market and vice versa.

We perform the analysis using historical rather than expectational measures of production uncertainty. Production forecasts which were available when Rolfo performed his analysis have been discontinued (Gil and Duffus), and the limited number of observations and the presence of a structural break in production makes the usefulness of other forecast methods (e.g., ARIMA) limited.

Following Rolfo (1980), the formulation distinguishes between the random actual cash prices ( $P$ ) when the hedge is lifted, and prices recorded on the futures exchange,  $f$  and  $P_f$ .  $P$  is the stochastic cash price received by COCOBOD and reflects world cocoa cash prices plus a quality premium specified in the forward contracts offered by the European buyers. Both futures contract settlement price and the cash prices are used in computing optimal joint price-output hedge ratios. The revenue function of the cocoa exporter exposed to simultaneous price and output risks in the absence of transaction costs is defined in (1),

$$(1) R = PQ + h(f - P_f),$$

where  $Q$  is the random quantity,  $h$  is the futures position,  $f$  is the futures price on the day the hedge is placed and  $P_f$  is the futures settlement price recorded on the last trading day. The returns or cocoa export revenue,  $R$ , are the sum of the returns in the cash market, and the returns the exporter realizes from transactions in the futures markets. When transaction costs are incorporated, the revenue function in (1) can be re-written as in (2),

$$(2) R = PQ + h(f - P_f - b),$$

where  $b$  in (2) is the transaction costs in the form of per unit brokerage fees. The utility maximization problem (UMP) of the Ghana cocoa marketing board is modeled first with quadratic utility then with a constant relative risk aversion (CRRA) utility function  $U(.)$  where  $U(.)' > 0$ ,  $U'' < 0$ , and the utility function is concave. Utility is defined as a function of export revenue ( $R$ ).

#### *The Cocoa Exporter with Quadratic (Mean-Variance) Utility Function*

Quadratic utility which implies mean-variance preferences has extensive theoretical and empirical application in the literature (Peck, 1975; Rolfo, 1980; Chavas and Pope, 1982; Kahl, 1983; Alexander, Muser, and Mason, 1986; Lence, 1996, 2009). It is popular because of its

simplicity. The UMP with quadratic utility function is given in (3) where  $h$ , the futures position, is the choice variable in COCOBOD's Utility Maximization Problem.

$$(3) \text{ Max: } EU(\mu_R(R(h)), \sigma_R^2(R(h))) = \mu_R(R(h)) - \gamma \sigma_R^2(R(h)) =$$

$$E[E[PQ + h(f - P_f - b)] - \gamma E\{[PQ + h(f - P_f - b) - E[PQ + h(f - P_f - b)]]^2\}], \text{ and}$$

$\mu_R(R(h))$  and  $\sigma_R^2(R(h))$  are respectively the mean and variance of export revenue and  $\gamma$  is the risk parameter (the coefficient of relative risk aversion or CRRA). The optimal futures position obtained by solving (3) is given in (4)

(4)  $h = \text{covariance}[PQ, P_f] / \sigma_{P_f}^2 + E[(f - P_f - b) / 2\sigma_{P_f}^2 \gamma]$ , where  $\sigma_{P_f}^2$  is the variance of  $P_f$ . In equations (3) and (4),  $E$  is the mathematical expectation operator so the expected value of stochastic cocoa exporter revenue is,  $E(R) = \mu_R(R(h)) = E[PQ + h(f - P_f - b)]$  and the variance of stochastic revenue is  $\sigma_R^2(R(h)) = E\{[PQ + h(f - P_f - b) - E[PQ + h(f - P_f - b)]]^2\}$ . For clarity of presentation, in solving for  $h$  from the maximization of expected utility, we leave out the overall expectation sign ( $E$ ) because the utility itself is a function of mean and variances which are also defined using the expectation ( $E$ ) sign. However the computations are done with the correct expression of expected utility.

The first component of  $h$  in (4) is the pure revenue hedge, the coefficient of  $P_f$  in a linear regression where  $PQ$  is the dependent variable and  $P_f$  is the independent variable (Rolfo, 1980). The pure hedge is independent of the magnitude of the risk aversion parameter. However it does crucially depend on the sign of the correlation between output and the futures price at expiration with a positive correlation supportive of a hedge (Alexander, Muser, and Mason, 1986). The second term is the bias in futures price (Rolfo, 1980) less transaction costs. This bias (also called the speculative part of the hedge) is included for completeness but may be zero if risk aversion is



extremely high or if the market is efficient. If this speculative component is non-zero its magnitude depends on the risk aversion parameter. When transaction costs are zero, (4) is identical to Rolfo (1980)'s derivation.

#### *Cocoa Exporter with Nelson Escalante (2004) Utility Function*

Nelson and Escalante (2004) demonstrated that when the joint distribution of cash and futures returns are elliptically symmetric and final wealth satisfies the location-scale condition, expected utility can be written as a function of the first two moments of the return distribution (Chamberlain, 1983; and Meyer, 1987). We verified that final wealth satisfied the location-scale condition in the objective function developed using Nelson and Escalante's (2004) utility function. We used the Jacque-Bera test to ensure normality of returns as normality is an accepted form of elliptical symmetry. We thus maximize the expected utility of the Nelson and Escalante CRRA location-scale utility function as in (5)

$$(5) \text{Max: } EU(\mu_R(R(h)), \sigma_R^2(R(h))) = -1/(\mu_R(R(h))^2 - \gamma(\sigma_R^2(R(h)))) .$$

To maximizing (5), we simply maximize its denominator since both operations give the same answer. To identify  $h$  as the explicit choice variable, we re-write (5) as an explicit function of  $h$  and then maximize the denominator of the resulting function where  $h$  is the choice variable (6).

$$\begin{aligned} (6) \text{ Max: } & (\mu_R(R(h))^2 - \gamma\sigma_R^2(R(h))) = \\ & (E[(R(h))^2] - \gamma E[(R(h) - E[R(h)])^2]) = \\ & E[PQ + h(f - P_f - b)]^2 - \gamma E\{[PQ + h(f - P_f - b) - E[PQ + h(f - P_f - b)]]^2\} . \end{aligned}$$

Let  $\sigma_R^2(R(h))$  be defined as in (7)

$$(7) \sigma_R^2(R(h)) = E[R(h) - E(R(h))]^2 =$$

$$E[PQ - h(P_f - f - b)] - E[PQ - hb]]^2.$$

We can then solve the utility function in (8) for  $h$ , the optimal hedge position.

$$(8) \text{Max } E[PQ + h(P_f - f - b)]^2 - \gamma E\{[PQ + h(P_f - f - b) - E[PQ + h(P_f - f - b)]]^2\}.$$

A closed form solution to (8) can be obtained as long as we assume a zero basis (i.e., assuming  $P_f = P$ ) and is included in Appendix C. When we allow for non-zero basis, a more realistic case, a closed form solution is difficult to obtain but a search procedure similar to that employed by Rolfo (1980) and described in the next section can be developed to determine  $h$ , the optimal futures position and  $H$ , the optimal hedge ratio.

#### *The Optimal Hedge Ratio When Basis Risk Is Present*

In the presence of basis risk ( $P_f \neq P$ ), a search program was written in Visual Basic to solve for optimal hedge ratios. The search program uses the following algorithm: First set transaction costs,  $b = 0$ . For each pre-determined level of the hedge ratio ( $H = h / \mu_Q$ ) between 0 and 1 in steps of 0.01, obtain the value of the utility function for the twenty-eight observations from  $t = 1$  (1980) to  $t = 28$  (2008). Next sum the twenty-eight values and divide by twenty-eight to get the expected value of the utility function over the period for that value of  $H$ . Repeat the calculations for each value of  $H$  from 0.01...1.0. The value of  $H$  between 0 and 1 (0.01, 0.02...1.0) that corresponds to the highest expected value of the utility function over the period is the optimal hedge ratio. By repeating the search over the range of  $H$  values the optimal hedge can be found for different risk parameter values.

To identify the effects of transaction costs,  $b$  is included and changed and the process is repeated. The optimal hedge ratio corresponding to each level of transactions costs can then be

compared to the optimal hedge ratios when  $b = 0$  and those obtained from the MVH to determine how robust optimal joint hedge ratios are to changes in transaction costs and to preference type. For each pair of values of  $H$  and  $b$ , the expected utility can be computed and compared to the expected utility where  $H = 0$  and when both  $H$  and  $b$  have zero values. This enables a comparison of the utilities of a hedged and unhedged exporter given the presence or absence of transaction costs.

### 3.4 DESCRIPTION OF THE DATA

#### *Transaction costs*

Transaction costs can include a number of factors including information costs, monitoring costs, and actual monetary costs of trading related to brokerage fees. Transactions costs are modeled as brokerage fees, which constitute the largest component of transactions costs. Here we examine six levels of brokerage fees in \$/ton (0, 10, 50, 100, 200, and 500). The likely range of brokerage fees that COCOBOD will face is between \$0 and \$100 per ton. However transactions costs incorporate huge start up fixed costs and other financial requirements which when spread over the total number of contracts purchased will increase the transactions cost per contract significantly. For example, there are costs associated with training the risk managers at the marketing board to use the futures market. Alternatively a foreign risk management firm could be contracted but either option is expensive. We therefore use \$500/ton as the cut off point for transactions costs. Brokerage fees have been declining over the years and can normally be negotiated downward for large volume futures participants such as the COCOBOD. Brokerage fees vary depending on whether the hedge is large or small or whether the hedger wants full service or a per round term transaction. A very large prospective hedger such as the COCOBOD

can obtain between 25 and 60 dollars per ton. Smaller hedgers will pay substantially more in brokerage fees per ton.

#### *Cash, Futures and Futures at Expiration Data*

Hedge horizons were set at December to be consistent with Ghana's October-January, cocoa harvest season (COCOBOD, 2000). Cocoa futures and output data from 1980-2008 were obtained respectively from the New York Board of Trade (NYBOT) and the Ghana cocoa marketing board (COCOBOD). The NYBOT was used because it is liquid and because the cocoa contract traded has specifications that are compatible with the cocoa SSA countries export. As will be explained later, however, almost no Ghanaian cocoa sells in NY because of high transport costs and quality premium.

Table 3.2 (on the next page) contains summary statistics for cocoa production and revenue for Ghana as well as for the futures and spot prices used in the research. The standard deviations of prices, revenue and production (assumed to reflect exports since in-country storage is minimal) indicate that there is substantial price, production and revenue risk. Further, the mean of the cash prices received by COCOBOD for delivery (1775.4) exceeds both the mean of July futures forecast price (1514.2), and the mean of the futures price for December expiration (1553.2). These differences are likely indicative of the premium paid by buyers for Ghana's premium cocoa. Also, note that since the mean of the futures price at expiration is greater than the July futures forecast price, the optimal hedge is an increasing function of the risk parameter (Outtara, Schroeder, and Sorenson, 1990).

Table 3.2 Summary Statistics for Annual Prices, Production and Revenues, Ghana, 1980-2008

Production (* 1000 tonnes)	Mean	Std. Dev.	Min	Max
Ghana	498.85	69.79	360.05	653.32
Random Revenue (*\$1000)				
Ghana	885640.8	281240.4	353567.6	1301458
Prices (\$)	Mean	Std. Dev.	Min	Max
Cash	1775.37	453.72	890	2690
Futures at Expiration	1553.22	441	877	2469
Futures Forecast	1514.22	440.36	692	2513

Table 3.3 Correlations and Covariances between Cash and Futures Prices, 1980-2008

	Futures price	Cash price	Futures at expiration
Futures price	1		
	( 194477)		
Cash price	0.86	1	
	( 171581)	(205861)	
Futures at	0.9	0.96	1
expiration	( 174761)	(205861)	( 195679)

Variance and Covariances are in parentheses.

At \$222, the basis at contract expiration is unusually large, about 12.5 percent of the spot price. This basis (\$222/ton) is primarily due to separate quality premiums paid for all West African cocoa and for Ghanaian cocoa in particular because Ghana cocoa is the world's highest quality cocoa. The NYBOT offers quality premiums of \$160/ton for West African cocoa but does not differentiate among the different types of West Africa cocoa (Ghana, CIV, Togo, Nigeria, Cameroon and Benin). Gilbert (2009) suggests that Ghanaian cocoa draws a premium of 3 to 5 percent relative to CIV and other West African cocoa in forward contracts. Assuming the futures price is reflective of the world market price, the Ghanaian price reflects the futures price at expiration (\$1553) plus the quality premium paid to other West African producers (\$160), and the

added premium identified by Gilbert. This leads to an average Ghanaian price of \$1781.52/ton  $[(1553+160) \times 1.04]$  which is quite close to the \$1775.40 reported by the Board.

The standard deviation of futures prices is smaller than that for spot prices, a favorable occurrence for very risk-averse agents and very volatile markets such as the cocoa market. This is because when the futures are less risky than the cash price, risk management using futures contracts is typically more effective. Table 3.3 contains results of correlation and covariance between the futures price, the futures price at expiration and the random spot price. It is clear that the futures at expiration are strongly correlated with the spot price. Correlation between all prices is high ranging from 0.9 to 1. This strong correlation between the futures at expiration and spot prices from the forward contracts suggests that hedging can still be an effective management tool despite a price premium or basis of \$222/ton paid for Ghanaian cocoa.

### 3.5 RESULTS

Table 3.4 Optimal Hedge Ratios at Different Values of the Risk Parameter for Quadratic Utility for Ghana as a Cocoa Exporter

Risk Aversion Parameter ( $\gamma$ )	b=0 Ghana
$\infty$	0.44
1000	0.44
100	0.44
10	0.44
4	0.44
3	0.44
2	0.44
1	0.44
0.1	0.44
0.01	0.44
0.001	0.43
0.0001	0.41
0.00001	0.12
0.0000001	-1.00
0.00000001	-1.01
Cash hedge	0.82
Pure Revenue Hedge	0.44

Results presented here come from the analysis with de-trended revenue and non-detrended futures prices but are not much different from when no de-trending is done or when both cash and futures are de-trended. The pure price hedge (minimum variance hedge), computed at infinite risk aversion, zero production risk and zero transaction costs which is measured as the coefficient of the futures price from the regression of cash on futures is 0.82 as shown in Table 3.4. This means, faced with just price risk, a typical cocoa exporter like Ghana should hedge 82% of output in order to obtain a level utility from export revenue greater than the unhedged position (zero hedge). Table 3.4 also displays optimal “revenue hedge ratios” for Ghana using quadratic utility for values of the risk parameter  $\gamma$  between 0.000000001 and  $\infty$  which represent the range from a risk loving to an extremely risk averse cocoa exporter. An identical range was used by Rolfo (1980) so results make for an interesting comparison with his work.

When  $\gamma = \infty$ , the second term drops out in equation (4) and we get the pure revenue hedge (Rolfo, 1980; Outtara, Schroeder and Sorenson, 1990). The pure revenue hedge (with infinite risk aversion), for quadratic utility is 0.44 as shown in Table 3.4. When we allow less than infinite risk aversion, for all levels of  $\gamma$  larger than 0.001, the revenue hedge is also 0.44. In comparison, Rolfo (1980) finds using quadratic utility that the optimal revenue hedge ratios for Ghana, is 0.6 for  $\gamma$  larger than 0.001 so our results are only slightly different from Rolfo’s.

Since we are using data after the 1978 structural break, the market analyzed is somewhat different. Therefore we expect to find similar but not identical results as Rolfo (1980) when we use the quadratic utility function. From Table 3.4, the optimal hedge ratios do not vary much with  $\gamma$ , but similar to the results reported by Rolfo, and Outtara, Schroeder, and Sorenson (1990) they drop precipitously at lower levels of  $\gamma$ . Here the threshold value of  $\gamma$  is 0.0001. The conclusion

from the analysis using quadratic utility and zero transactions costs is that Ghana would benefit from hedging cocoa export revenue albeit to a small extent.

Table 3.5 Comparisons of Optimal Hedge Ratios (MVH) for Ghana at a Value of the Risk parameter ( $\gamma$ ) of 4 and at Different Transactions Costs Using Quadratic Utility

Transaction costs (\$ b) given $\gamma=4$	Ghana
0	0.44
10	0.38
20	-1
50	-1
100	-1
200	-1

When transactions costs are incorporated optimal hedge ratios decline. Transactions costs alter optimal hedge ratios at a  $\gamma$  or CCRA of 4 corresponding to a CARA of 0.000005 using quadratic utility. A CCRA of 4 employed as it is typical in the literature for risk analysis. From Table 3.5, between \$0 and \$10 dollars/ton, the optimal hedge ratio shrinks from 0.44 to 0.38. This represents a 6 percentage point decline in the optimal hedge ratio. At any value of the transactions cost greater than \$10, the optimal hedge ratio is negative meaning a long hedge is superior to a short hedge. A negative (long) hedge ratio means that the cocoa marketing board should go long both the commodity and the futures contract. However, this is impractical here since it amounts to speculation and increases risk.



Table 3.6 Optimal Hedge Ratios at Different Values of CRRA for NE 2004 Utility for Different Values of the CRRA risk Parameter for Ghana

Risk Aversion Parameter ( $\gamma$ )	b=0 Ghana
$\infty$	0.31
1000	0.31
100	0.31
10	0.31
4	0.31
3	0.31
2	0.31
1	0.31
0.1	0.31
0.01	0.31
0.001	0.31
0.0001	0.31
0.00001	0.1
0.0000001	-0.96
0.00000001	-19.96
Cash hedge	0.819
Pure Revenue Hedge	0.31

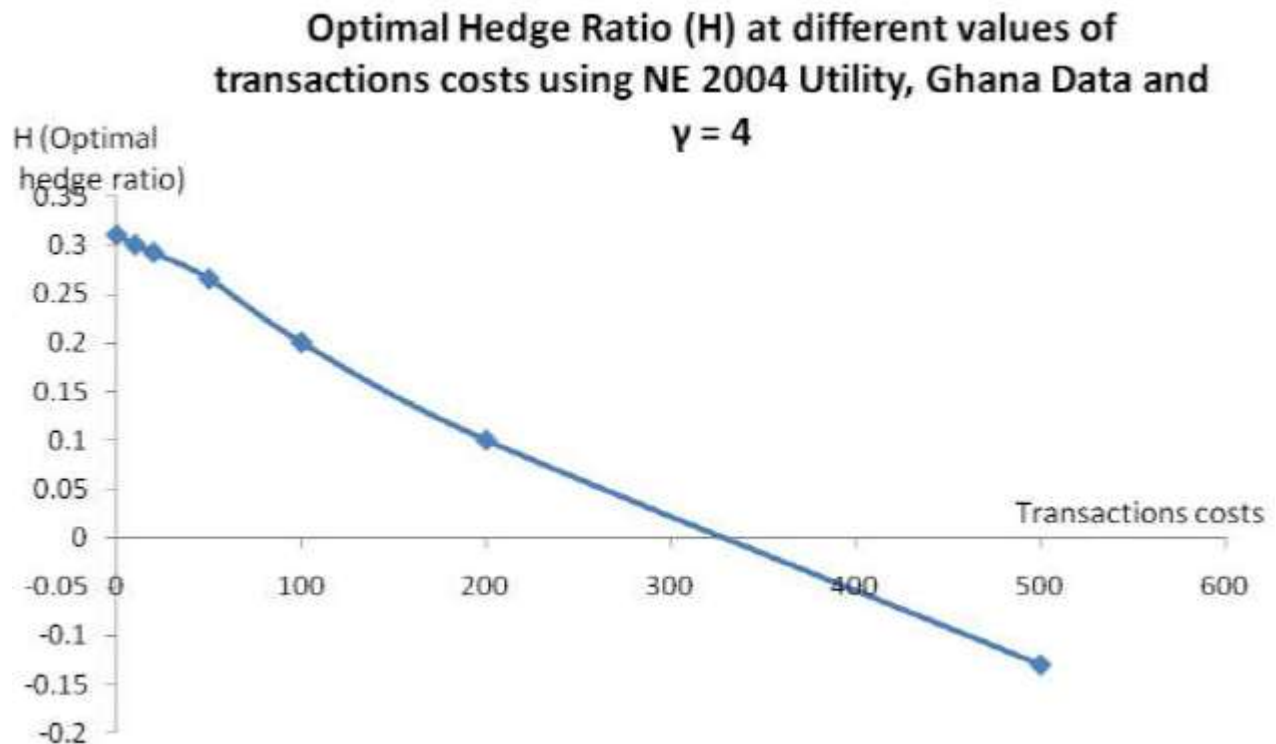
When we compute optimal hedge ratios with the more realistic CRRA utility function (Nelson and Escalante, 2004), the results differ from the quadratic utility. From Table 3.6, the pure revenue hedge ratio (infinite risk aversion) for Ghana, computed at zero transactions costs using the more representative Nelson and Escalante (2004) utility function is 0.31. This is comparable to the finding of Rolfo for log utility (which is also a CRRA utility function but has a fixed CRRA  $\gamma$  value of 1). The fact that the CRRA utility functions (Nelson and Escalante, 2004) display smaller hedge ratios than the quadratic utility is to be expected because the former also displays decreasing absolute risk prudence which means it is less sensitive to risk (Chen, Wang, and Mittelhammer, 2006). Insensitivity to risk implies that as revenues increase COCOBOD is unlikely to seek more protection from risk because its preferences are not sensitive to risk. An

agent with quadratic utility is more sensitive to risk as revenues increase and will seek more protection from risk leading to higher optimal hedge ratios. Since the CRRA utility represents more believable preference we put more weight on these results.

The optimal hedge ratios using CRRA utility are fairly constant at different values of the risk parameter ( $\gamma$ ). From Table 3.6, the optimal hedge ratio for Ghana remains constant at 0.31 at CRRA risk parameter value ( $\gamma$ ) greater than 0.0000001, then turns negative. The constant optimal hedge ratio for values for the range of  $\gamma$  between infinity and 0.0000001 indicates that the speculative component of the hedge is inconsequential. For the range of  $\gamma$  greater than 0.0000001 or for risk lovers, the speculative part of the hedge dominates so the hedger is net long (Outarra, Schroeder, and Sorenson, 1990). A long hedge here implies speculation which is not desirable here given the risk minimization objective outlined in COCOBOD's UMP.

Similar to the results of the quadratic utility analysis, the optimal hedge declines monotonically at risk parameter value ( $\gamma$ ) of 4 for fairly reasonable values of transactions cost (\$0 to \$100 per ton). For Ghana, transactions costs appear to exert considerable influence on optimal hedge ratios using the Nelson and Escalante (2004) utility function although the transaction cost effect is less dramatic than in the quadratic utility case.

Figure 3.3 OHR at different Transaction Costs,  $\gamma = 4$  and using NE 2004 Utility



Data Source: Export Revenue data were obtained from the Ghana Cocoa Marketing Board.

From Figure 3.3, between \$0 and \$100/ton, the hedge ratio declines from a value of 0.31 (the pure revenue hedge) to 0.2. Ultimately, beyond a transaction cost/ton of \$350 hedging is a moot question because the transaction costs per ton are simply too high.

Transaction costs have many components not all of which has been accounted for by brokerage fees. In particular for a SSA country such as Ghana, there are large hidden costs such as the cost of educating the would-be risk managers at the Ghana Cocoa Marketing Board about futures markets and contracts as well as other financial requirements for using future contracts all of which will increase the relevant feasible range of transactions contracts. Still it is unlikely that the transactions costs paid per contract will be as high as \$350. The results using Nelson and Escalante's (2004) utility suggest optimal hedge ratios for the Ghana Cocoa Marketing Board remain positive even after transactions costs are considered. Based on these results, limited use of

the futures market appears to be optimal for Ghana when we take transaction costs into account given reasonable values of the risk parameter.

### 3.6 CONCLUSIONS

SSA cocoa producers such as Ghana are typically exposed to both production and price risk which results in revenue risk. Revenue risk can be managed using futures contracts. However, the use of futures markets incorporates costs that may outweigh the benefits. This analysis investigated the effect of transaction costs and risk tolerance on the optimal hedge using cocoa revenue data from Ghana and both quadratic utility and Nelson and Escalante's (2004) CRRA utility functions. Results confirm Rolfo's (1980) finding that the optimal hedge is increasing in the risk parameter for both utility functions for the range of data used. However, using quadratic utility and reasonable values of the risk parameter, we obtain very small positive hedge ratios without considering transaction costs which quickly disappear with modest transaction costs

In comparison using the Nelson and Escalante (2004) utility function which is a more believable representation of preferences, we obtain small positive values for the optimal hedge ratios even when transactions costs are considered. Since the optimal hedge ratio is the solution of a utility maximization problem, Ghana's use of the futures market is superior to the no hedging situation.

Despite the potential benefits identified using the more representative Nelson and Escalante (2004) utility function, the results indicate that Ghana should hedge considerably less than full output when facing pure price risk. When faced with revenue risk, Ghana should hedge significantly less than when facing pure price risk. Finally when transactions costs are considered, the scope for hedging is reduced even more.

### 3.7 EXTENSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Although this paper does not focus on the enhanced reputation dimension of the benefits of hedging revenue risk, following Malone (2005), it would be interesting to simulate the reduction in the probability of sovereign default risk that a smoothened cocoa export revenue risk from hedging implies. The reduction in cost of sovereign borrowing from different degrees of income smoothing due to hedging should also provide valuable information to policy-makers.

More detailed analysis of the effect of transportation costs on the optimal hedge ratios and on the utility from hedging revenue risk will also provide pertinent information for Ghanaian policy makers. Incorporation of the utility derived from reduced borrowing rates and decreased probability of sovereign default on loans (that hedging entails) into the utility maximization problem of the cocoa-exporting SSA sovereign are also useful candidates for further research.

Another interesting line for research is to investigate why the NYBOT contracts do not have mechanisms to recognize whatever is special about Ghana cocoa. Is the answer simply because it is not cost effective from the NYBOT perspective since Ghana cocoa can sell for more to European buyers than top Americans because Europe is closer? Or is the quality of Ghana cocoa just not valuable to the American cocoa processor and chocolate producers?

Further research could also investigate if the structure of domestic cocoa marketing in Ghana is likely to change from a focus on production exclusively for export to a focus on processing the produced cocoa and whether that change will reduce risks for COCOBOD making risk management less of an issue. In particular, as Prebisch and Singer (1954) have argued, terms of trade decline over time for primary products like cocoa so it might be a good idea for the producers of primary products to move up the chain into processing. It can plausibly be argued that since comparative advantage is dynamic not static by investing in technology, Ghana might

actually secure a comparative advantage in processing cocoa over time which can help it process more cocoa beans. If Ghana substantially increases the proportion of cocoa beans processed domestically then hedging against output price variation of cocoa beans becomes less relevant. However, increased processing will not eliminate marketing problems completely for the COCOBOD. New risks associated with developing and maintaining an effective supply chain and new challenges of competing with established firms in the final product market will emerge. Further, as processing increases, returns and risk from the complete supply chain operations become important, and pricing of the input cocoa beans to both support producer well-being and provide sufficient returns with an acceptable risk will be relevant.

The move into processing in part will depend on whether the value added per ton of processing more than compensates for the lost premiums per ton selling raw cocoa beans. Preliminary research by Pinnamang-Tutu and Armah (2011), suggests that the value added from processing seems to be increasing over time and in turn, the tonnage processed by Ghana is increasing slowly. Nevertheless, at the moment 80% of total production is still exported. Research that identifies what combination of total beans produced should be exported and what percentage should be processed in Ghana will be valuable information for Ghanaian cocoa policy makers seeking to maximize sovereign welfare from cocoa export revenue.

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## CONCLUSIONS TO THE DISSERTATION

This three essay dissertation evaluated the usefulness of marketing-based and aid-based strategies in spurring growth and economic development in Sub-Saharan Africa (SSA). The conclusion from Essay 1 that conditional on political stability, aid contributes to growth in SSA has important consequences for aid policy and should stimulate further research into the factors that help to achieve and sustain stability in SSA. Essay 1 also helped to resolve the aid-growth debate for SSA; Aid helps in SSA countries conditional on political stability. Further, the marginal effect of growth with respect to aid for SSA was found to be non-trivial so aid was confirmed as a viable strategy for growth promotion in SSA.

Essay 2, the first of two papers evaluating the applicability of market-based strategies to SSA, determined whether the cocoa futures market is efficient as efficiency is a desirable condition for using futures as a market-based risk management strategy. Revenue risk-management with futures markets was shown to be a viable strategy to hedge cocoa revenue risk because cocoa futures markets were found to be unbiased and efficient in both short and long runs. Further, costs due to risk premiums are negligible. Although private agents can make money in the short run using information from historical time series, the money made is irrelevant on a risk-adjusted basis. The futures market thus satisfies the sufficient condition for informational efficiency and does not contain a risk premium. This means the cost of using the futures markets either through non-accurate hedges or through payments made as compensation by short hedgers to speculators is insignificant. It is therefore feasible to use cocoa futures to minimize revenue risk.

Essay 3 investigates the usefulness of hedging with futures markets for the Ghanaian cocoa exporter in a utility maximizing framework. In contrast to previous research, I allow for non-zero basis, and a more realistic utility function (which displays risk vulnerability and

decreasing absolute risk prudence). Using annual data on prices and production, optimal hedge ratios were then determined by solving the utility maximization problem facing the Ghanaian cocoa exporter. Hedge ratios for Ghana are considerably less than one, but positive for relevant ranges of risk parameters and transaction costs. As a consequence hedging appears to be utility improving, but the amount hedged is only a small proportion of total production.

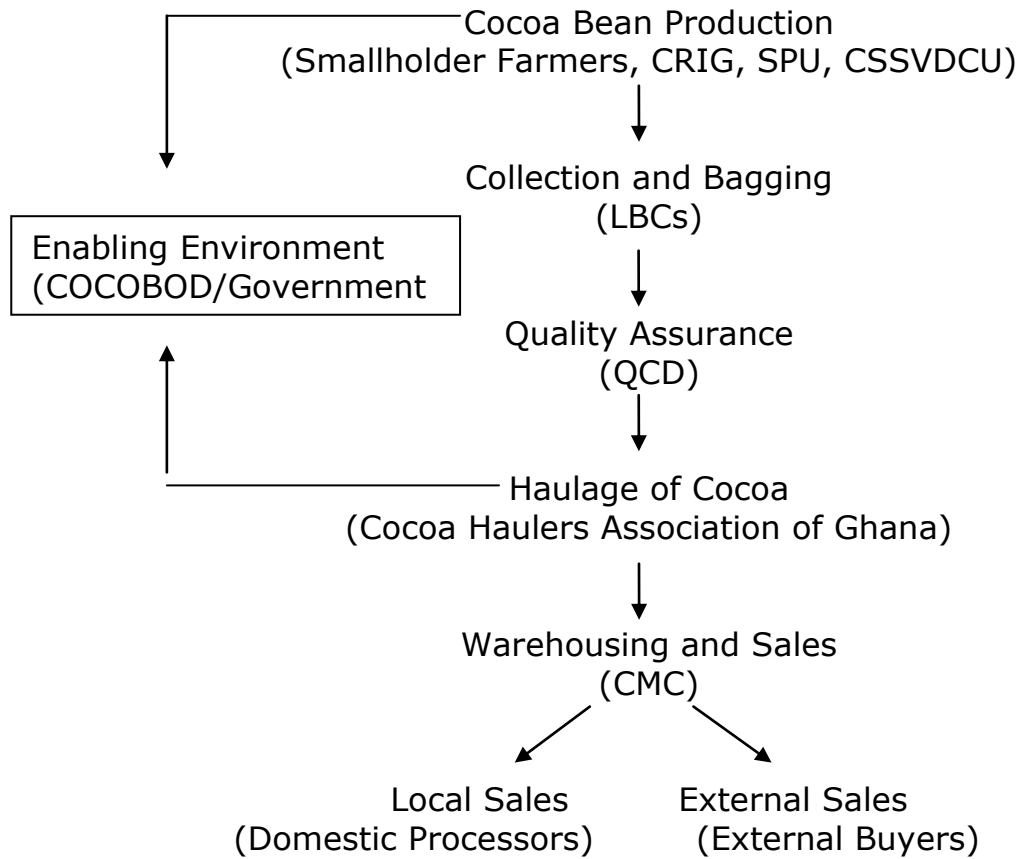
In conclusion, I note that while Essay 1 establishes aid as a credible development strategy albeit only in politically stable SSA countries, Essay 2 suggests that market risk management with futures markets is a viable development strategy for SSA. Essay 3 however concluded that although hedging is potentially feasible, the magnitude of production protected using futures contracts will be small. Aid, political stability and market strategies thus emerge as complementary tools to spur growth in SSA.

In particular, if we conceptualize foreign aid as part of total capital inflow and the use of futures markets as smoothing the capital inflow in some way, then hedging and foreign aid work in concert to promote growth contingent on political stability. While aid increases the flow of capital, hedging minimizes its variability resulting in robust growth as long as political conditions are favorable to turn capital into wealth.

## Appendix A

<i>Millennium Development Goals</i>	<i>Targets</i>
1. Eradicate extreme poverty and hunger.	i. Reduce by half the number of people living on less than \$1/day. ii. Reduce by half the proportion of people who suffer from hunger.
2. Achieve universal primary education.	i. Ensure that all boys and girls complete a full course of primary schooling
3. Promote gender equality & empower women.	i. Eliminate gender disparity in primary and secondary school education, preferably by 2005, and at all levels by 2015.
4. Reduce child mortality.	i. Reduce by two thirds the mortality rate among children under 5.
5. Improve maternal health.	i. Reduce by three-quarters the maternal mortality ratio.
6. Combat HIV/AIDS malaria and other major diseases.	i. Halt and begin to reverse the spread of HIV/AIDS. ii. Halt and begin to reverse the incidence of malaria and other major diseases.
7. Ensure Environmental sustainability.	i. Integrate the principles of sustainable development into country policies & programs, reverse loss of environmental resources. ii. Reduce by 1/2 the number of people w/o sustainable access to safe drinking water. iii. Achieve significant improvement in the lives of at least 100 million slum dwellers by 2020.
8. Develop a global partnership for development.	i. Develop further an open rule based, predictable, non-discriminatory trading and financial system; Includes a commitment to good governance, poverty reduction both nationally and internationally. Address the special needs of the least developed countries; includes tariffs and quota free access for LDC exports; enhanced debt relief for the heavily indebted poor countries (HIPC) and cancellation of official bilateral debt; and more generous development assistance (ODA) for countries committed to poverty reduction. ii. Address the special needs of landlocked countries and small Island developing States. iii. In cooperation with developing countries, develop, and implement strategies that with generate employment for the youth. iv. In cooperation with pharmaceutical companies provide access to affordable and essential drugs in developing countries. v. In cooperation with the private sector, make available new technology especially in IT & communication.

Appendix B  
Ghana's Unique Domestic Cocoa Supply Chain



LBC: Licensed Buying Agent

SPU: Seed Production Unit

CRIG: Cocoa Research Institute of Ghana

CCVDCU: Cocoa Swollen Shoot Virus Disease Control Unit

CMC: Cocoa Marketing Company

Source: Pinnamang-Tutu (2010).

## Appendix C

### The Closed-form Optimal Solution for the Optimal Hedge When Basis Risk is Absent

Here  $P = P_f$  so we can use that information to solve the utility function in (A.1) for  $h$ , the optimal hedge position.

$$(A.1) \quad \text{Max} \quad E[PQ + h(P_f - f - b)]^2 - \gamma E\{[PQ + h(P_f - f - b) - E[PQ + h(P_f - f - b)]]^2\}.$$

A closed form solution to (8) can be obtained if we assume no basis risk (i.e., assuming  $P_f = P$ ) and is included in this appendix. When we allow for basis risk a closed form solution is difficult to obtain but a search procedure similar to that employed by Rolfo (1980) can be developed to determine  $h$  and by implication the optimal hedge ratio. The search procedure is discussed in more detail in the text and is the procedure used to generate our results because it is more practical to assume non-zero basis risk. Assuming no basis risk so that  $P_f = P$ , we can expand the last term in (A.1) to get (A.2)

$$(A.2) \quad E[PQ - h(P_f - f - b) - E[PQ - hb]]^2 = \sigma_R^2(R(h)) \\ = E(P^2Q^2) - [PQ]^2 - 2hE(PQ(P - f)) + h^2E(P - f)^2.$$

Let  $h^2E(P - f)^2 = \sigma_{P_f}^2$  so we have (A.3),

$$(A.3) \quad \sigma_R^2(R(h)) = E(P^2Q^2) - [PQ]^2 - 2hE(PQ(P - f)) + h^2\sigma_{P_f}^2.$$

To solve for  $h$  we need only consider terms that contain  $h$  in (A.3). Expanding the last two terms in (A.3) by adding and subtracting  $f$  and  $\mu_Q$ , we obtain (A.4)

$$(A.4) \quad \sigma_R^2(R(h)) = h^2\sigma_{P_f}^2 - 2hE(\{P - f + f\}\{Q - \mu_Q + \mu_Q\}(P - f)),$$

where  $\mu_Q$  is the mean of output. Simplifying this expression, we arrive at (A.5)

$$(A.5) \quad \sigma_R^2(R(h)) = h^2\sigma_{P_f}^2 - 2hE(\{P - f\}^2\{Q - \mu_Q\}) + 2h\sigma_{P_f}^2 + 2hfE(\{P - f\}\{Q - \mu_Q\}).$$



Let  $E(\{P-f\}\{Q-\mu_Q\}) = \text{covariance}(P, Q) = \rho \sigma_{pf} \sigma_Q$  where  $\rho$  is the correlation coefficient between  $P$  and  $Q$ , and  $\sigma_{pf}$  and  $\sigma_Q$  are respectively the standard deviation of  $P (= P_f)$  and  $Q$ . So now we have (A.6),

$$(A.6) \quad \sigma_R^2(R(h)) = h^2 \sigma_{P_f}^2 - 2hE(\{P-f\}^2\{Q-\mu_Q\}) - 2h\mu_Q \sigma_{P_f}^2 - 2hf \rho \sigma_{pf} \sigma_Q.$$

The maximization problem now becomes

$$(A.7) \quad \text{Max } E[PQ + h(P_f - f - b)]^2 - \gamma(E\{h^2 \sigma_{P_f}^2 - 2hE[(P - f)^2\{Q - \mu_Q\} - 2h\mu_Q \sigma_{P_f}^2 - 2hf \rho \sigma_{pf} \sigma_Q]).$$

The futures position,  $h$ , is the solution of the optimization problem in (A.7) and is given by (A.8),

$$(A.8) \quad h = [2 \gamma E(\{P-f\}^2\{Q-\mu_Q\})] / [2 \gamma \sigma_{P_f}^2 - 2b^2] + [2 \gamma f \rho \sigma_{P_f} \sigma_Q + \mu_Q \sigma_{P_f}^2] / [2 \gamma \sigma_{P_f}^2 - 2b] - [2bE(PQ)] / [2 \gamma \sigma_{P_f}^2 - 2b].$$

Assuming normality, the third and fourth moments of the distribution of price, revenue and quantity are all zero so  $h$  is given by

$$(A.9) \quad h = [2 \gamma f \rho \sigma_{P_f} \sigma_Q + \mu_Q \sigma_{P_f}^2] / [2 \gamma \sigma_{P_f}^2 - 2b] - [2b E(PQ)] / [2 \gamma \sigma_{P_f}^2 - 2b].$$

Given normality, and in the absence of transactions costs,  $b = 0$  and we get

$$(A.10) \quad h = [f \rho \sigma_Q / \sigma_{P_f}] + \mu_Q.$$

The hedge ratio  $H = h / \mu_Q$  so from (A.10), we get (A.11)

$$(A.11) \quad H = \rho (f / \sigma_{P_f}) (\sigma_Q / \mu_Q) + 1.$$

Therefore if  $\rho$  is negative, both the correlation between  $Q$  and  $P$  and transactions costs ( $b$ ) will tend to reduce the optimal hedge ratio. Note that equation (A.11) has a very intuitive interpretation because  $(f / \sigma_{P_f})$  is the inverse of the coefficient of variation of futures price at expiration and  $(\sigma_Q / \mu_Q)$  is the coefficient of variation of stochastic output (Mackinnon, 1967).

Clearly if  $\rho < 0$  so that price and production are negatively related, then the optimal hedge ratio

is less than unity. This result is similar to the conclusions drawn by Mackinnon (1967) and Rolfo (1980): in the presence of production risk and no transactions costs the optimal hedge ratio is less than unity. The more negatively correlated are price and output, the smaller the optimal hedge ratio. If in addition, price and production are not correlated then we get (A.12),

$$(A.12) \quad \rho = 0 \text{ and } H = 1 \text{ in an unbiased futures market.}$$

The cocoa exporter should fully hedge output. The result  $H = 1$  is the usual case described by Hieronymus (1971) for a merchant faced only with price risk and has support in the literature (see Ederington, 1971; Rolfo, 1980 and McKinnon, 1967). If transactions costs are not zero then we get (A.13),

$$(A.13) \quad H = [2 \gamma f \rho \sigma_{pf} \sigma_Q + \mu_Q \sigma_{Pf}] / [2 \gamma \sigma_{Pf}^2 - 2b] \mu_Q - [2bE(PQ)] / \mu_Q [2 \gamma \sigma_{Pf}^2 - 2b].$$